1991

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Nebraska Water Survey Paper Number 69
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The Conservation and Survey Division of the University of Nebraska is the agency designated by statute to investigate and interpret the geologically related natural resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources.

The division is authorized to enter into agreements with federal agencies to engage in cooperative surveys and investigations in the state. Publications of the division and the cooperating agencies are available from the Conservation and Survey Division, University of Nebraska–Lincoln, Lincoln, Nebraska 68588-0517.

The Conservation and Survey Division provides information and educational programs to all people without regard to race, color, national origin, sex or handicap.

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Cooperative projects with

UNITED STATES GEOLOGICAL SURVEY
Dallas L. Peck, Director

Water Resources Division, Nebraska District
Michael V. Shulters, District Chief

December 1991

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Illustrations

(except hydrographs of observation wells)

Hydrographs of Observation Wells

Factors for Converting English Units to the International System of Units (SI)

Multiply English units	by	To obtain SI units
Length		
inches	25.4	millimeters
feet	.3048	meters
miles	1.609	kilometers
Area		
acres	4047	square meters
square miles	2.590	square kilometers
Volume		
acre-feet	1233	cubic meters
Flow		
gallons per minute	.00006309	cubic meters per second

Introduction

In 1930 the Conservation and Survey Division of the University of Nebraska and the U.S. Geological Survey began a cooperative water-level measurement program to observe and document, on a continuing basis, the changes in groundwater levels throughout Nebraska. This program includes evaluation of the adequacy and accuracy of the water-level information collected and provides a means for its storage, retrieval, and dissemination in an easily understood format.

This 37th annual report on Nebraska's groundwater levels summarizes the significant historic changes in water levels and the water-level changes during 1990. These changes are shown through the use of maps and hydrographs. This report also describes the availability of water-level data, provides information on changes in the water-level measurement program, and summarizes data on the two major causes of water-level changes: precipitation and groundwater use. Data on groundwater levels can be used in conjunction with other data to:

1) Determine the volume of groundwater in storage and its availability for use.
2) Assess the water-supply outlook by determining changes in the volume of groundwater in storage.
3) Identify areas where changes in groundwater levels might have an economic impact.
4) Assist state and local agencies in the formulation and administration of resource-management programs.
5) Determine or estimate the rate and direction of groundwater movement, specific yield of aquifers, baseflow of streams, sources and volumes of recharge, and locations and volumes of discharge.
6) Assess the validity of hydrogeologic interpretations and the assumptions used in developing models of the groundwater system.

The period of record for many observation wells is too short to adequately determine long-term changes in water levels. Where possible, however, an individual comparison is made between 1990 water levels and estimated predevelopment water levels. An estimated predevelopment water level is the approximate average water level at a well site prior to any development that significantly affected water levels near the well. All available water-level data collected prior to or during the early stages of development are used to estimate predevelopment water levels.

Prior to significant water-resources development, most groundwater systems were near equilibrium conditions; that is, long-term recharge was approximately equal to long-term discharge. In Nebraska, the natural equilibrium of groundwater systems has been altered by 1) discharge from irrigation wells; 2) recharge from infiltration of surface water applied to irrigated crops; 3) recharge due to deep percolation of seepage from irrigation storage and distribution systems; 4) discharge to constructed drainage systems; and 5) changes in land use that affect the amount of recharge an aquifer receives. In many parts of the state, water-level fluctuations resulting from natural conditions may be either masked or accentuated by water-level fluctuations resulting from human activities. Therefore, judgment must be exercised when evaluating the significance of water-level changes.

Generally, water-level changes from spring or fall of one year to spring or fall of the next year are less than 1 foot, unless natural conditions or human activities significantly affect the water levels. Human activities can cause significant water-level changes, but more commonly such activities accentuate changes caused by nature. During a drought, groundwater levels generally decline because the small volume of water available to recharge the aquifer is less than the natural discharge through evapotranspiration (evaporation and transpiration by plants) and seepage. Increased use of groundwater for irrigation, public, and domestic supplies during a drought causes further declines in water levels. Conversely, when precipitation during a growing season is greater than normal, water levels tend to rise, or at least decline at a slower rate, because natural recharge to the aquifer equals or exceeds the natural discharge through evapotranspiration and seepage. At the same time, use of groundwater to supply human needs is lessened, so the effects of pumpage on water levels is less.

In order to describe water-level changes in more detail, the state has been divided into nine divisions: Southeast, Northeast, East South-Central, West South-Central, Central, East North-Central, Southwest, West North-Central, and Panhandle. Division boundaries coincide with natural resources district (NRD) boundaries, and each division includes the areas of two or more NRDs. Observation recorder wells provide representative water-level information for various parts of each division. Hydrographs showing water-level fluctuations in these wells are included in the descriptions of water-level changes in each division. For the readers' convenience, water-level hydrographs are explained at the end of the report.

In Nebraska, where use of water for irrigation results in the most significant water-level fluctuations, most observation wells are measured in the spring and late fall. Spring measurements are useful for determining the volume of groundwater in storage each year prior to irrigation. Fall measurements are useful for evaluating the effects of irrigation and for delineating problem areas, or the potential for them, more accurately; fall measurements are used in this report to document the long-term changes in water levels. In the summaries of water-level changes in the East South-Central and the Southwest divisions, changes between estimated predevelopment water levels and spring 1990 water levels also are described because they provide information useful in the management of the groundwater control areas located in these divisions.

Nebraska's water-level measurement program includes the collection of more data than are presented in this report. These additional data are available on request from the Conservation and Survey Division or the Nebraska District of the U.S. Geological Survey.

Changes in Water Levels, 1990

Water levels declined throughout most of Nebraska during 1990.

During 1990, water levels declined throughout many areas of Nebraska. Most of the declines were the result of continuing slightly less-than-normal to substantially less-than-normal dormant-season precipitation (October-March). The 1990 yearly precipitation totals were nearly normal for all of the eight climatological divisions except the Southeast Division, which had slightly less-than-normal precipitation. However, half of the climatological divisions had slightly less-than-normal precipitation during the 1990 growing season (April to September), and the remaining divisions had near normal precipitation.

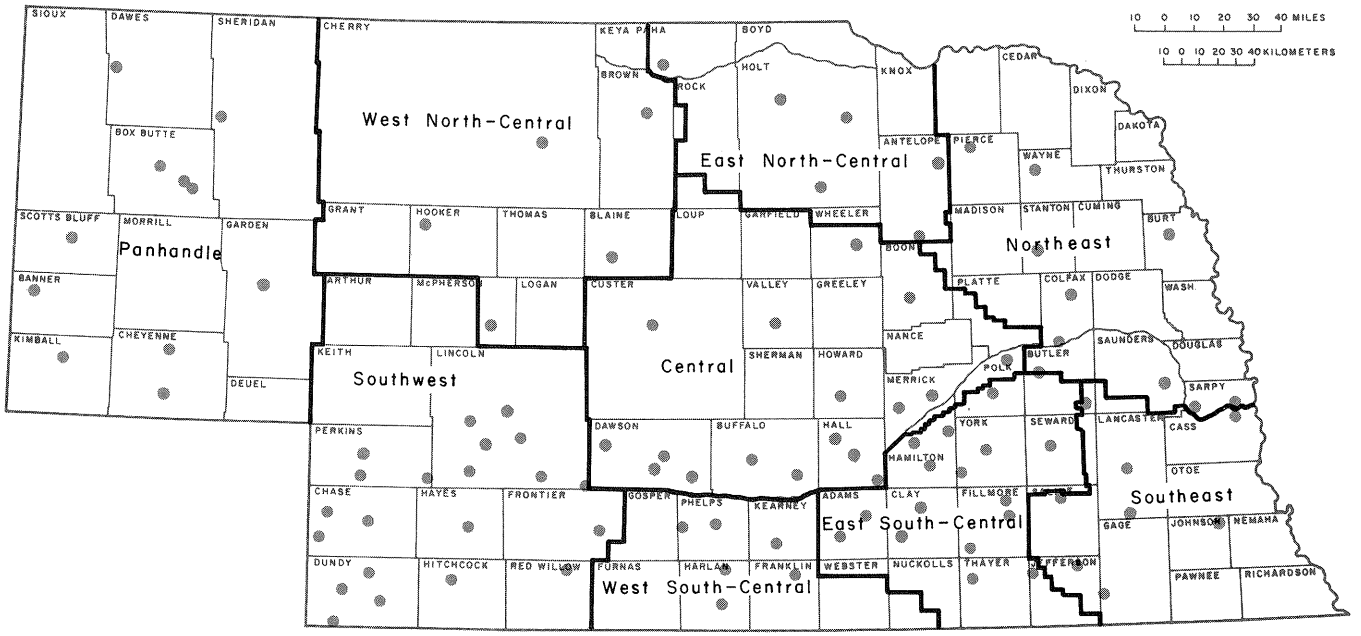
Following a 7-year rise in water levels, which ended in 1987, large areas in the Central, West South-Central and Southwest divisions continued the third year of fall water levels that were 1 to 5 feet lower. The same trend in large areas of the Northeast and East North-Central divisions, which started earlier than 1987, is still prominent for northeastern Nebraska. Although the East South-Central Division had large areas of 1- to 2-foot declines from fall 1989 to fall 1990, it also had a large area in the northern section of the division where water levels rose 1 to 5 feet. Box Butte County of the Panhandle Division nearly reversed its 1989 trend of decline and Buffalo, Dawson, and Hall counties of the Central Division nearly reversed their 1989 trends of rising levels. For those divisions with declining water levels, the result has been that many fall 1990 water levels were 5 to 90 feet below estimated predevelopment water levels. In the Central, East South-Central, and Southwest divisions, most of the declines in 1990 were in or near the large areas where declines of 5 to 49 feet from estimated predevelopment levels have existed for many years. During 1990, the size of the decline area of 5 to 42 feet in the East South-Central Division increased by about 6,400 acres, and the size of the decline areas in Hall, Buffalo, Dawson, and southwestern Custer counties increased by about 15,000 acres.

Although most fall 1989 to fall 1990 water levels rose in the delineated areas in Box Butte County in the Panhandle Division, these rises were still not sufficient to lessen the areal extent of the zones of declines from estimated predevelopment to fall 1990.

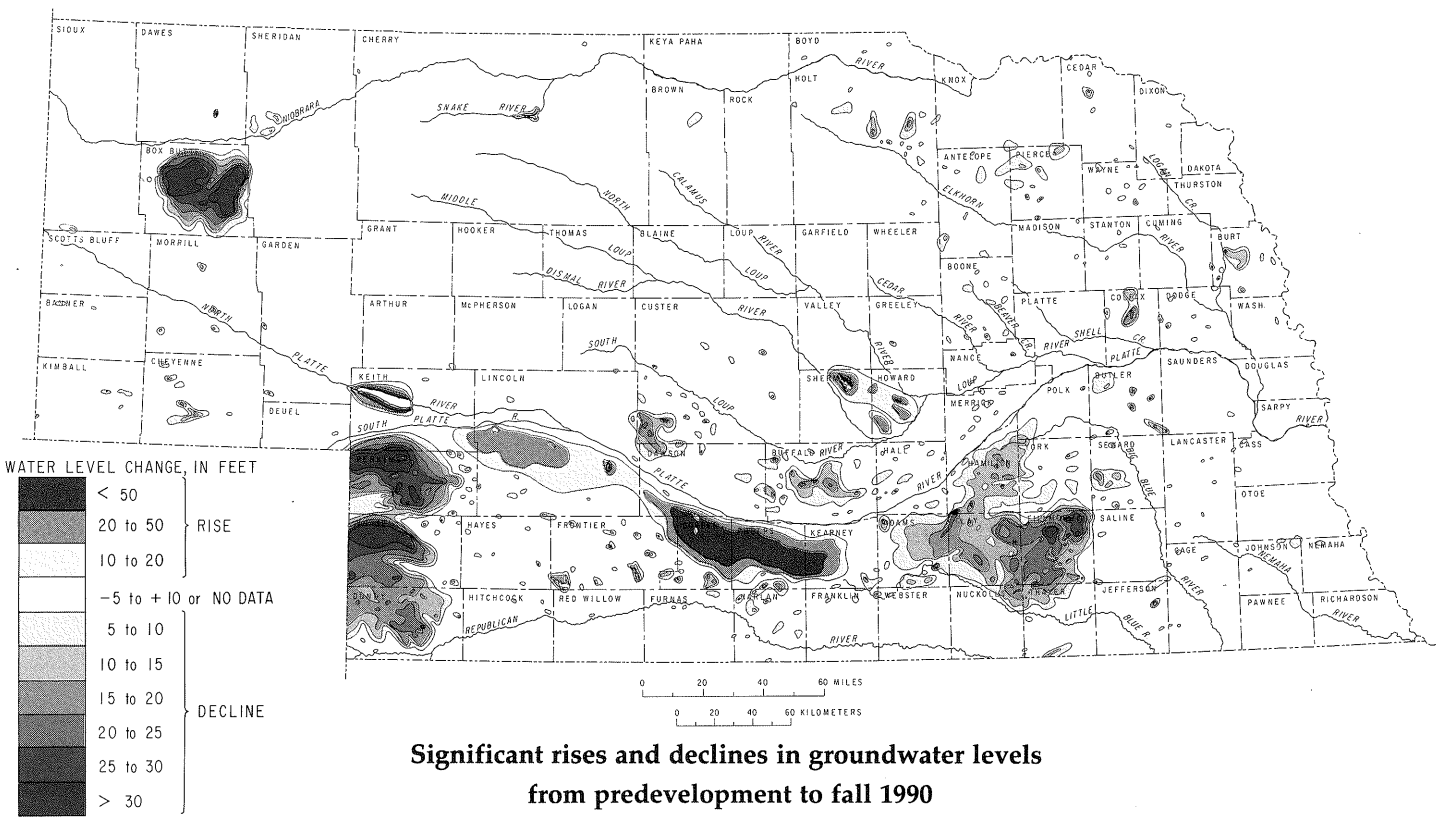
Where no significant declines or rises from estimated predevelopment water levels have occurred, the hydrologic system usually is in an approximate state of equilibrium. That is, the volume of recharge to the aquifer is balanced by the volume of discharge.

Groundwater levels around larger reservoirs are considered to be approximately in equilibrium with average annual reservoir stage. The groundwater rises from predevelopment to present around large reservoirs that are illustrated in this report are similar to those shown in previous water-level reports, which were based on evaluations of data provided by irrigation districts. Water-level change intervals were estimated from the water-level data obtained from observation wells and the density of irrigation wells.

Comparison of estimated predevelopment water levels with fall 1990 water levels allows for the delineation of most areas where significant long-term declines or rises in water levels have resulted from the development of water resources. Declines of 5 to 90 feet have occurred under about 4.28 million acres and rises of 10 to 90 feet have occurred under about 1.51 million acres. The water-level data collected in 1990 are sufficient to define the major areas where significant water-level declines or rises have occurred.



Location of wells with hydrographs and boundaries of divisions



Significant rises and declines in groundwater levels from predevelopment to fall 1990

Differences Between 1989 and 1990 Water Levels

In most parts of Nebraska, groundwater levels measured in observation wells during both the spring and fall of 1990 were lower than water levels measured in the spring and fall of 1989. Spring 1990 water levels were lower than spring 1989 water levels in about 73 percent of the wells measured. The average spring 1990 water level was 0.71 foot lower than the average spring 1989 level. Fall 1990 water levels were lower than fall 1989 water levels in about 69 percent of the observation wells, with the fall of 1990 water levels averaging 0.56 foot lower than the fall of 1989 water levels.

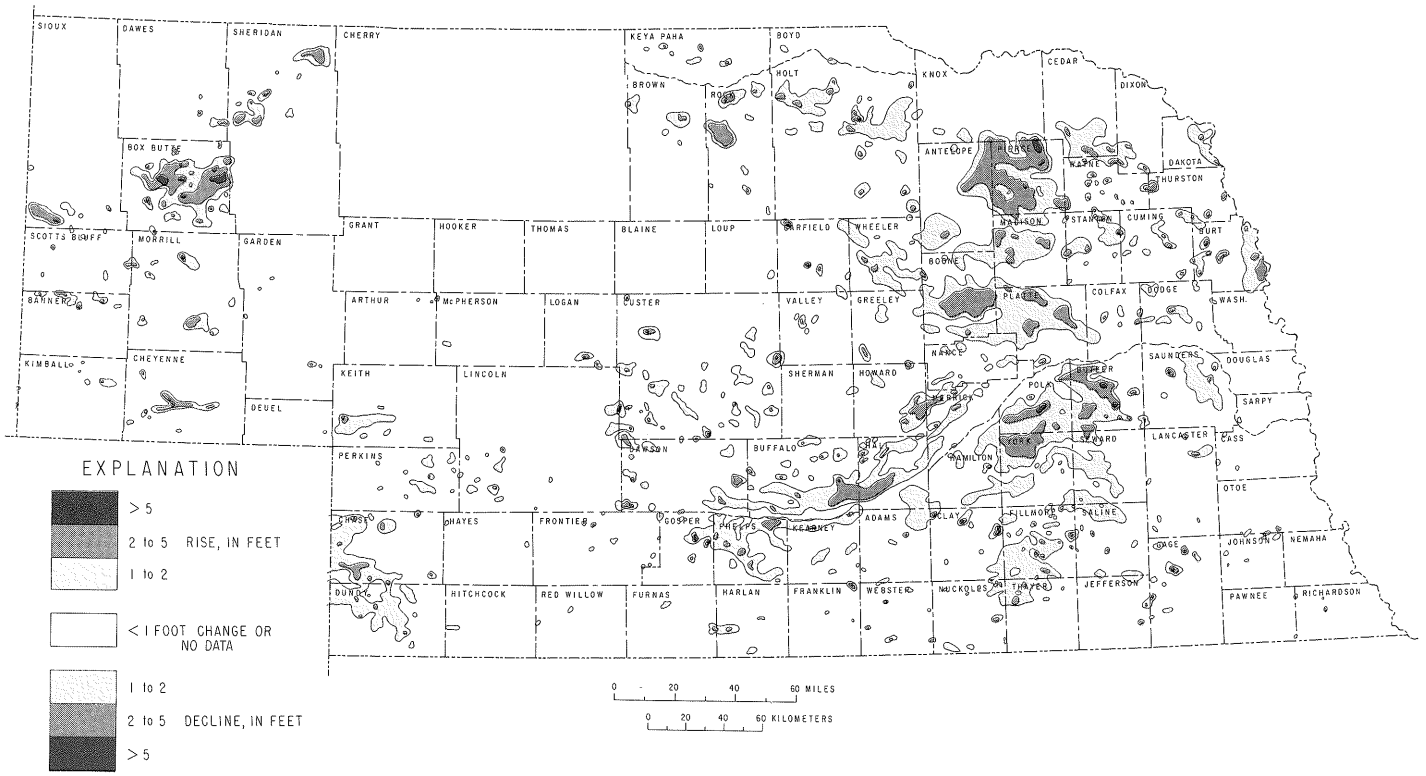
Spring 1990 water levels were lower than spring 1989 water levels in 73 percent of the observation wells in Nebraska.

Most of the water levels measured in observation wells in eastern Nebraska in the spring of 1990 were at least 1 foot lower than the water levels measured in the spring of 1989. In the Northeast and East South-Central divisions, there were large areas where most spring 1990 water levels ranged between 2 and 5 feet lower than spring 1989 water levels. Within these divisions, many spring 1990 water levels were at least 5 feet lower than spring 1989 water levels.

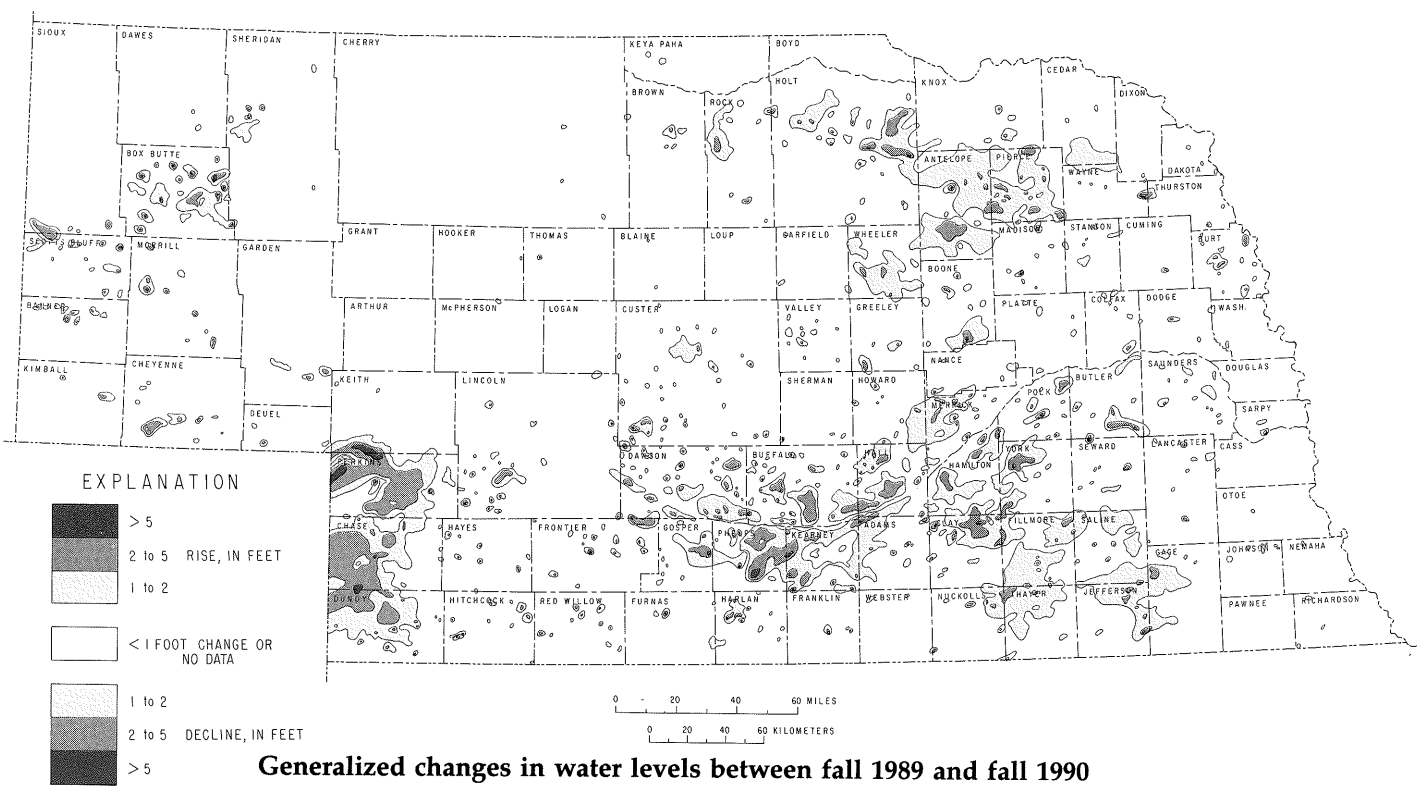
In the central part of Nebraska, most spring 1990 water levels were 1 to 2 feet higher than those read the previous spring. There were some areas scattered throughout the central part where water levels rose 2 to 5 feet from the spring of 1989 to the spring of 1990, along with isolated areas having rises greater than 5 feet.

In the western part of Nebraska, many water levels measured in observation wells in the spring of 1990 ranged between 1 and 2 feet lower than the water levels measured in the spring of 1989. Most of these declining areas occurred in areas already delineated as having water-level declines from the estimated predevelopment to the present. In Box Butte County (Panhandle Division), spring 1990 water levels have declined from 2 to 5 feet, and in some areas declines of up to 25 feet from spring 1989 have occurred.

Water levels measured in observation wells in the fall of 1990 generally were lower than water levels measured in the fall of 1989, except in the northeastern part of the East South-Central Division and parts of the Panhandle and West South-Central divisions, where in several areas fall 1990 water levels were at least 1 foot higher than the fall 1989 water levels. In the Central, Southwest, West South-Central, and scattered areas of the East North-Central and Northeast divisions, many fall 1990 water levels were 2 to 5 feet lower than those of fall 1989.



Generalized changes in water levels between spring 1989 and spring 1990



Generalized changes in water levels between fall 1989 and fall 1990

Southeast Division

Groundwater levels in the Southeast Division generally were lower during 1990 than during 1989. About 79 percent of approximately 3,300 water levels measured in the spring of 1990 were lower than those measured in the spring of 1989. Most spring 1990 water levels were less then 1 foot lower than the spring 1989 water levels; however, water-level declines of as much as 4 feet occurred in Saline and Gage counties. During the fall of 1990, groundwater levels in most parts of the division were slightly lower than the fall 1989 water levels. About 86 percent of approximately 3,700 water levels measured in the fall of 1990 were lower than those measured in the fall of 1989. Most fall 1990 water levels were less than 1 foot lower than fall 1989 water levels.

In the Southeast Division 79 percent of the water levels measured in the spring of 1990 were lower than those measured in the spring of 1989.

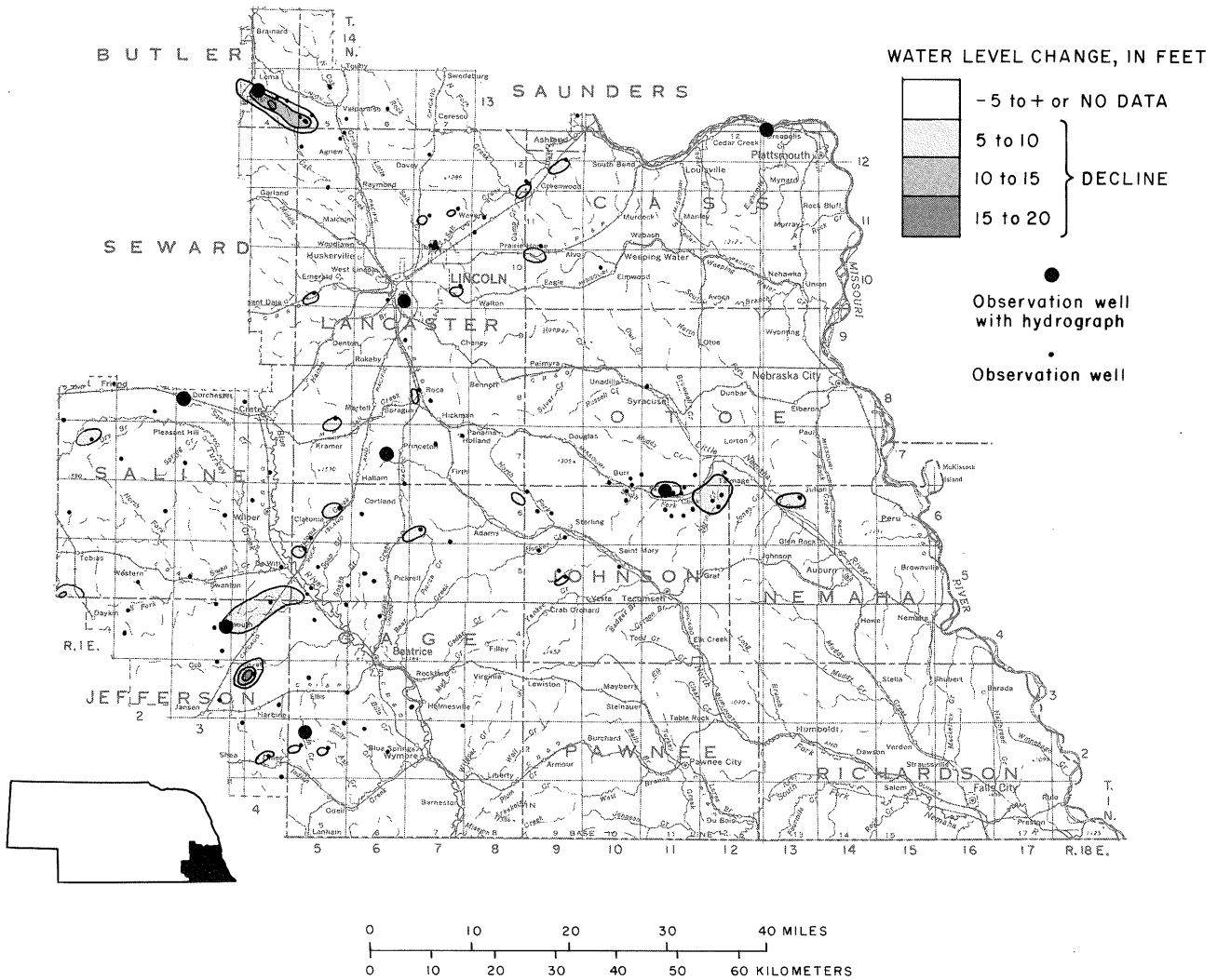
Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	140	79	-0.81
Fall	151	86	- .84

The availability of groundwater supplies that are adequate for supporting irrigation development is limited primarily to areas in the western part of the division. About 88 percent of approximately 2,200 irrigation wells in the division are located in Gage, Jefferson, Lancaster, and Saline counties. Seventeen new irrigation wells were drilled and registered in the division during 1990. (Numbers of registered irrigation wells used in this report are based on computer records of the Nebraska Department of Water Resources. Revisions occasionally are made in these records to reflect new information.)

During the fall of 1990, water-level declines of 5 to 7 feet from estimated predevelopment levels occurred in limited areas in Jefferson, Butler, and Saunders counties. The sum of these areas, which generally coincides with areas where groundwater is used for irrigation, is about 25,000 acres.

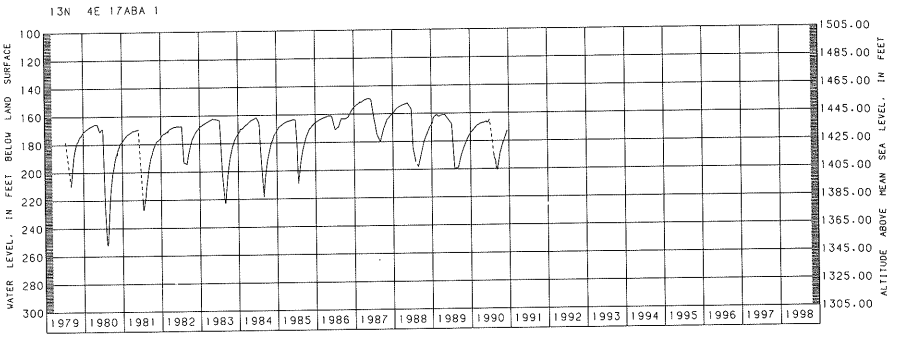
Estimated predevelopment water levels in the division are based on water levels measured prior to 1951. Data needed to determine predevelopment levels are sufficient only in the western part of the division. Water levels measured by the Lower Big Blue, Lower Platte South, and Nemaha natural resources districts, along with those measured by the U.S. Geological Survey and the Conservation and Survey Division, provide sufficient data for determining current water-level changes in most of the division.



Areas of significant water-level change in the Southeast Division from 1951 to fall 1990

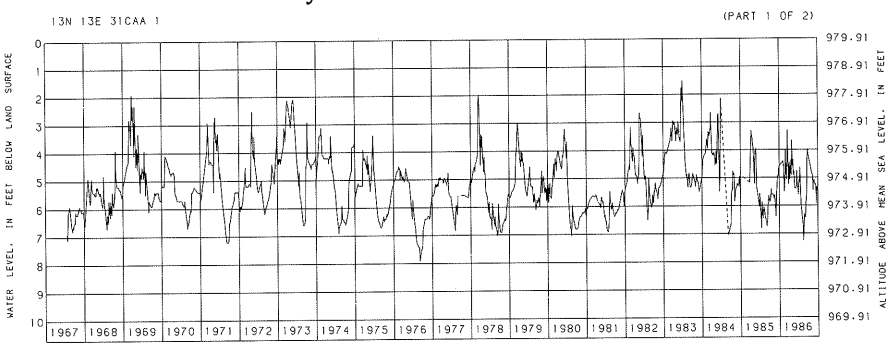
Butler County: Dwight North Recorder Well

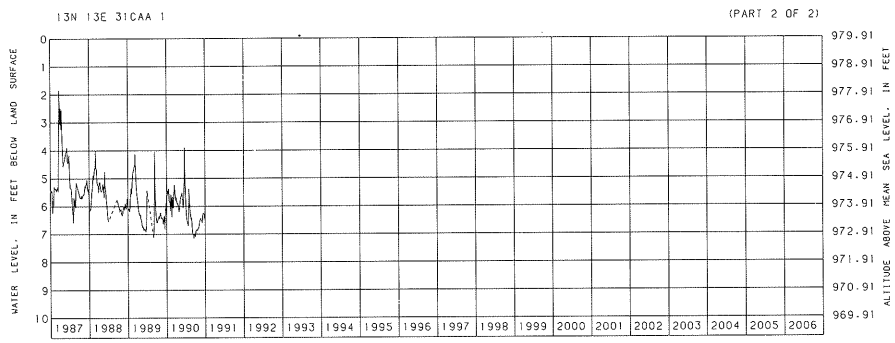
Estimated predevelopment water level: 163 feet
Net water-level change in 1990: +4.06 feet
Net water-level change since 1979: +0.94 foot



Cass County: MUD Number 4 Recorder Well

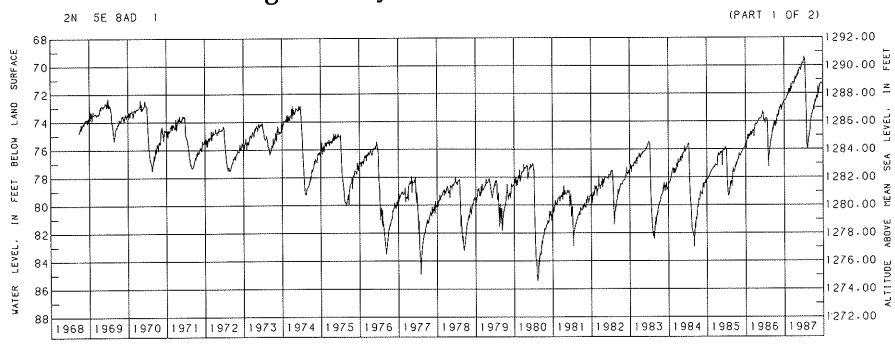
Estimated predevelopment water level: 4.5 feet
Net water-level change in 1990: -0.53 foot
Net water-level change since 1967: +0.25 foot



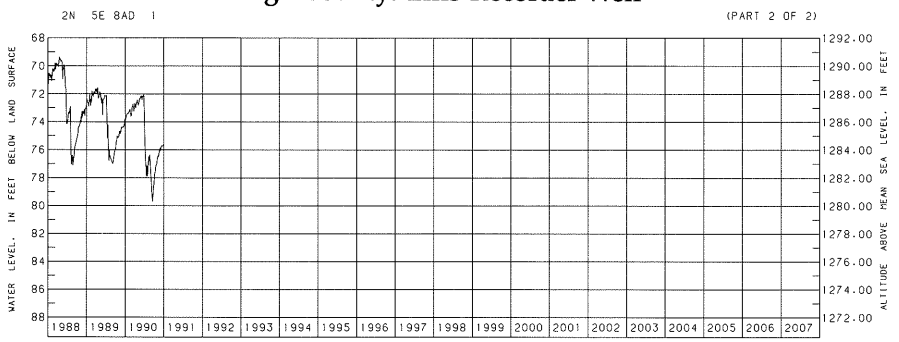


Gage County: Ellis Recorder Well

Estimated predevelopment water level: 73 feet
Net water-level change in 1990: -1.74 feet
Net water-level change since 1968: -1.54 feet

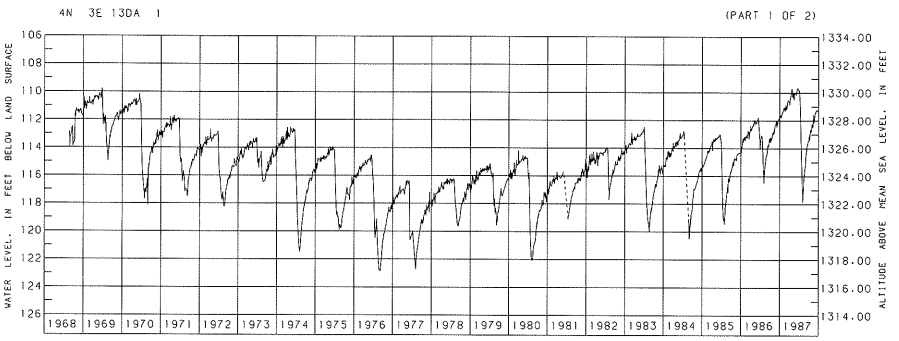


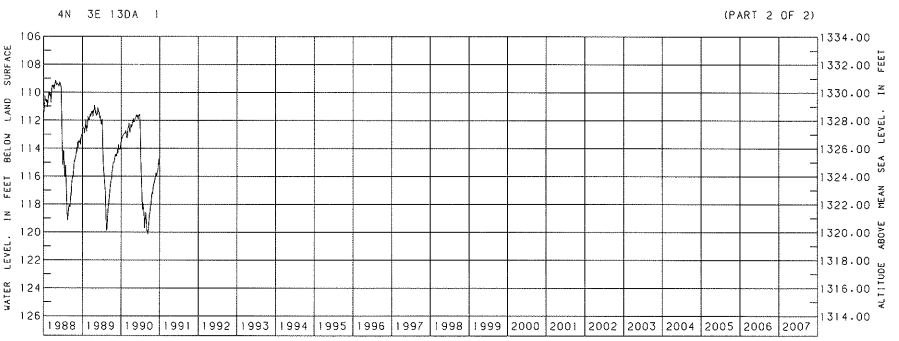
Gage County: Ellis Recorder Well



Jefferson County: Plymouth Recorder Well

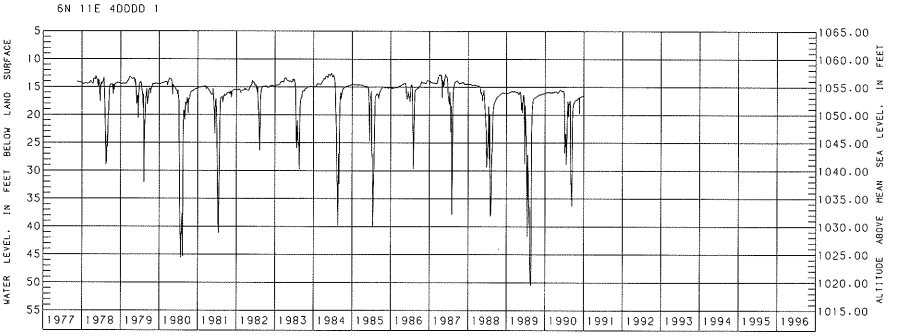
Estimated predevelopment water level: 107 feet
Net water-level change in 1990: -1.94 feet
Net water-level change since 1968: -3.99 feet





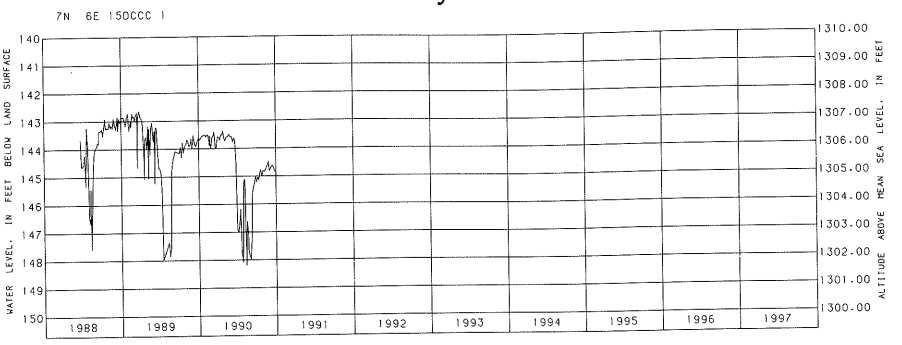
Johnson County: Cook Recorder Well

Estimated predevelopment water level: 13 feet
Net water-level change in 1990: -0.49 foot
Net water-level change since 1977: -2.26 feet



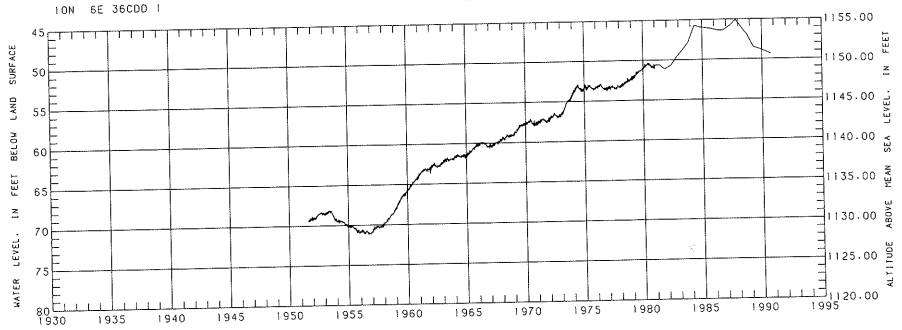
Lancaster County: Princeton Recorder Well

Estimated predevelopment water level: 143 feet
Net water-level change in 1990: -1.21 feet
Net water-level change since 1988: -1.94 feet



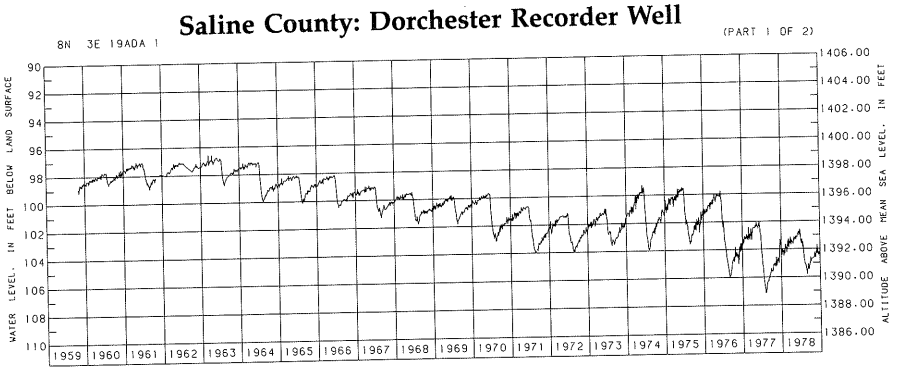
Lancaster County: Van Dorn Well

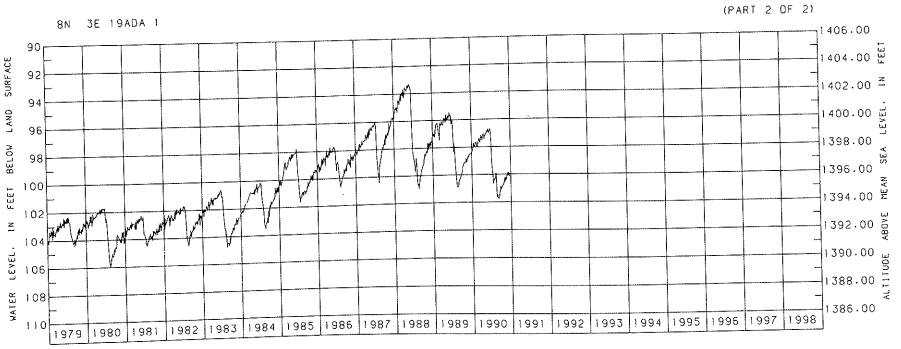
Measured annually
Estimated predevelopment water level: 35 feet
Net water-level change, fall 1989 to fall 1990: -0.66 foot
Net water-level change since 1951: +19.80 feet



Saline County: Dorchester Recorder Well

Estimated predevelopment water level: 97 feet
Net water-level change in 1990: -1.29 feet
Net water-level change since 1959: -1.61 feet





Northeast Division

Groundwater levels measured in the Northeast Division in the spring and fall of 1990 generally were lower than those measured in the spring and fall of 1989. Water levels in 92 percent of the 388 wells measured in the spring of 1990 were lower than those measured in spring of 1989. Most of the declines ranged from about 1.5 to 4 feet; the greatest declines, about 10 feet, were in Pierce County. In the fall of 1990, water levels in 68 percent of the 479 wells measured were lower than those measured in the fall of 1989. Most of the declines in the fall of 1990 were less then 1 foot. Isolated areas of rising water levels are scattered throughout the division, with most of them occurring in the eastern half. In Wayne County, fall 1990 water levels rose by as much as 8 feet from fall 1989 levels.

Spring 1990 water levels in the Northeast Division averaged 1.79 feet lower than spring 1989 water levels.

Differences between water levels measured in 1990 and those measured in 1989 were:

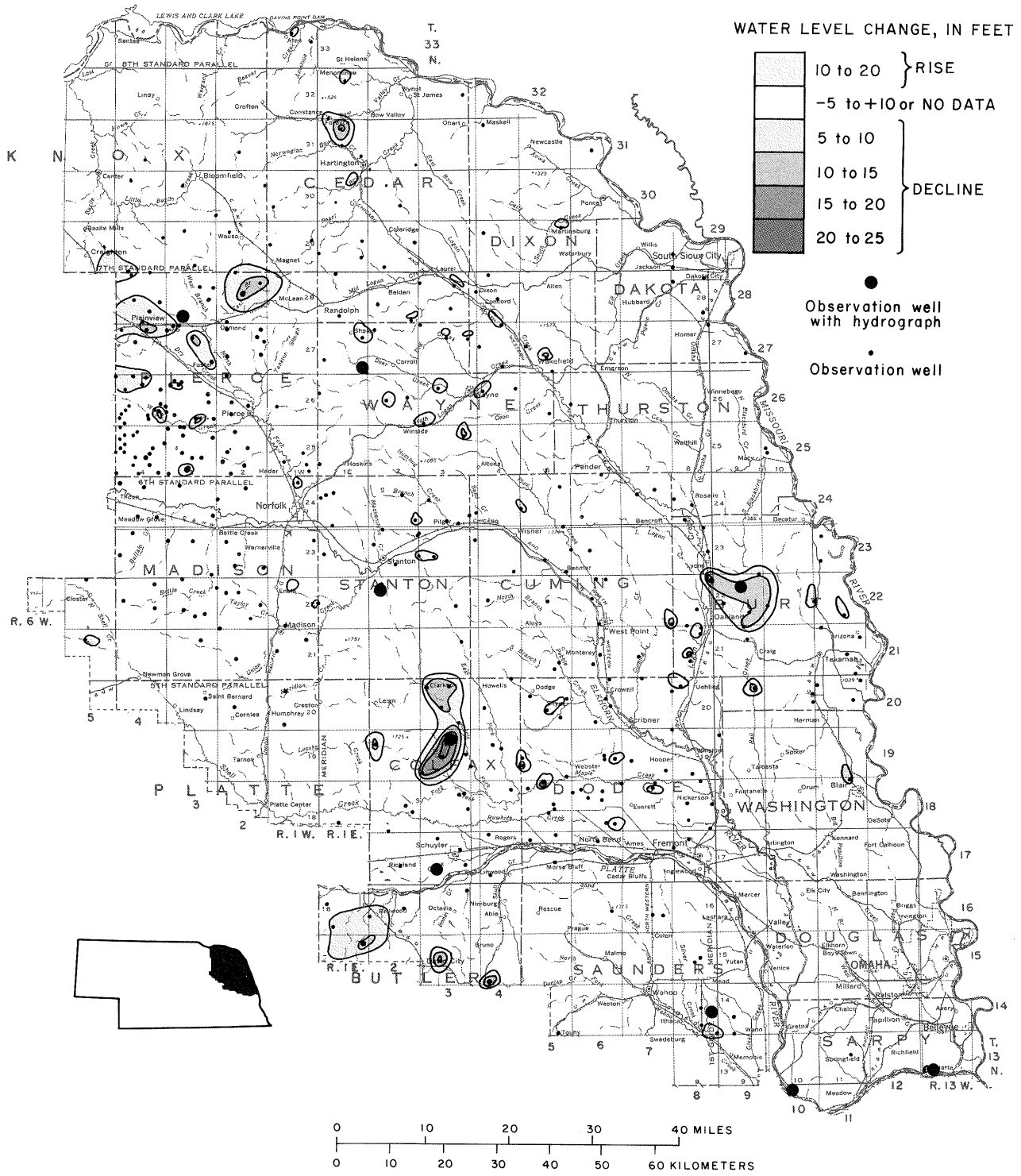
Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	388	92	-1.79
Fall	479	68	- .44

Fall 1990 water-level measurements indicate that areas of decline of more than 5 feet from estimated predevelopment levels occurred within almost all of the counties included in the Northeast Division. The largest area where fall 1990 water levels declined at least 5 feet from estimated predevelopment water levels was approximately 33,000 acres in northern Colfax County. The largest water-level decline from the estimated predevelopment level was about 34 feet in a well located in north-central Pierce County. This area has been increasing steadily since first occurring in the fall of 1987. The declines probably are the result of irrigation-well density and less-than-normal precipitation during the last 2 months of the 1990 growing season.

Development of groundwater resources for irrigation began in the 1930s and accelerated in the early 1950s and mid-1970s because of droughts during those periods. During the 41-year period from 1950 through 1990, the number of irrigation wells installed and registered increased from about 300 to about 8,200, with 140 new wells drilled during 1990.

Declines from estimated predevelopment water levels, in most parts of the Northeast Division, usually are the result of pumpage during the irrigation season. Past spring measurements show that such declines generally are seasonal, and the water levels generally recover to near estimated predevelopment levels by the start of the next irrigation season. If a prolonged drought causes a large increase in water pumped and a large decrease in recharge to the aquifer, progressive declines in water levels might occur in these areas.

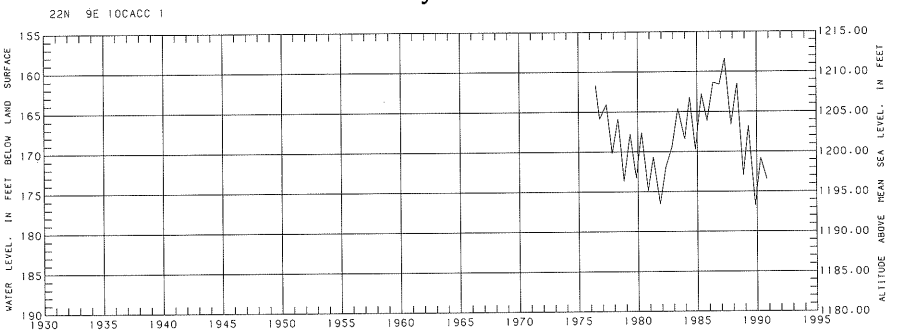
Sufficient data are available to provide reasonably good estimates of predevelopment water levels and current water-level changes throughout most of this division. Water-level measurements were made by the Lewis and Clark, Lower Elkhorn, Lower Platte North, and Papio-Missouri River natural resources districts, as well as the Conservation and Survey Division and the U.S. Geological Survey.



Areas of significant water-level change in the Northeast Division from 1930 to fall 1990

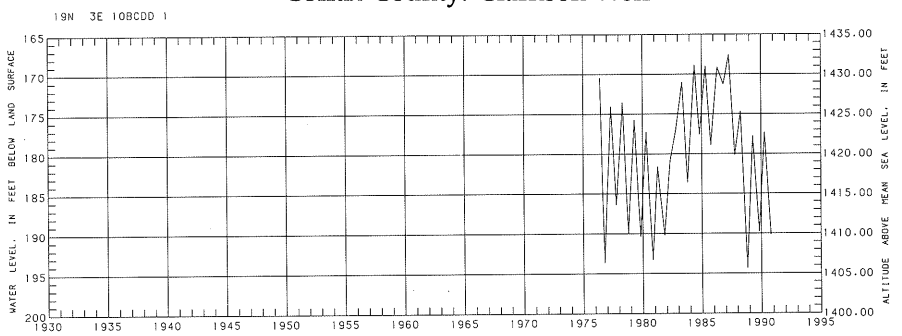
Burt County: Oakland Well

Measured semiannually
Estimated predevelopment water level: 161 feet
Net water-level change, fall 1989 to fall 1990: +3.29 feet
Net water-level change since 1976: -7.54 feet



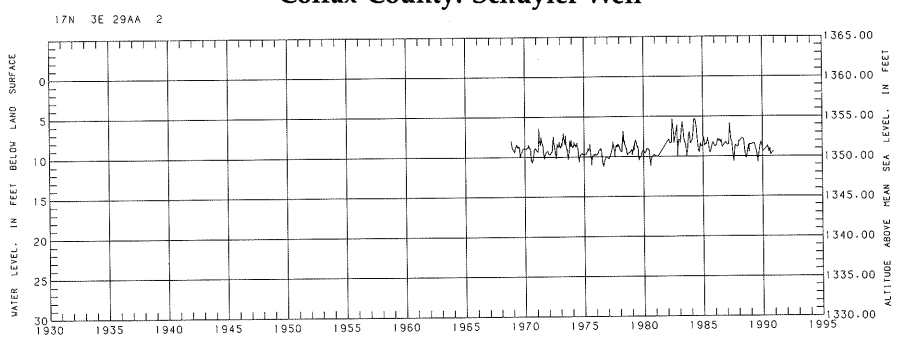
Colfax County: Clarkson Well

Measured semiannually
Estimated predevelopment water level: 169 feet
Net water-level change, fall 1989 to fall 1990: -0.37 foot
Net water-level change since 1976: +3.48 feet



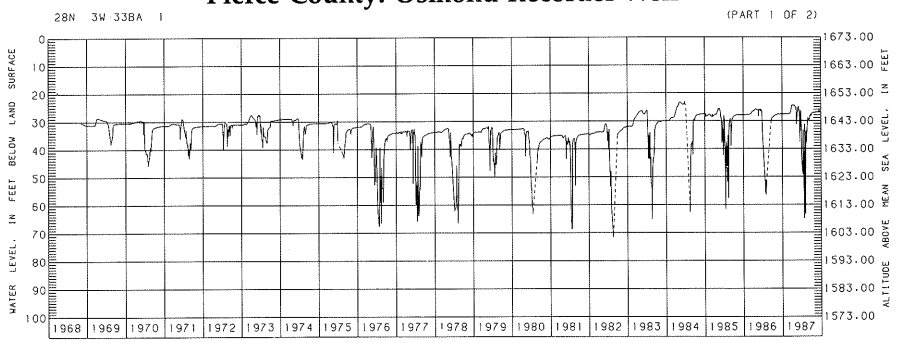
Colfax County: Schuyler Well

Measured monthly
Estimated predevelopment water level: 7.5 feet
Net water-level change in 1990: -0.32 foot
Net water-level change since 1968: -0.52 foot

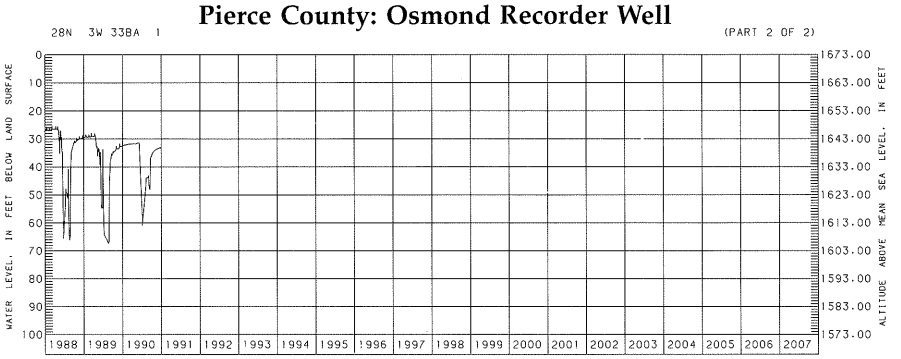


Pierce County: Osmond Recorder Well

Estimated predevelopment water level: 29 feet
Net water-level change in 1990: -0.64 foot
Net water-level change since 1968: -1.96 feet

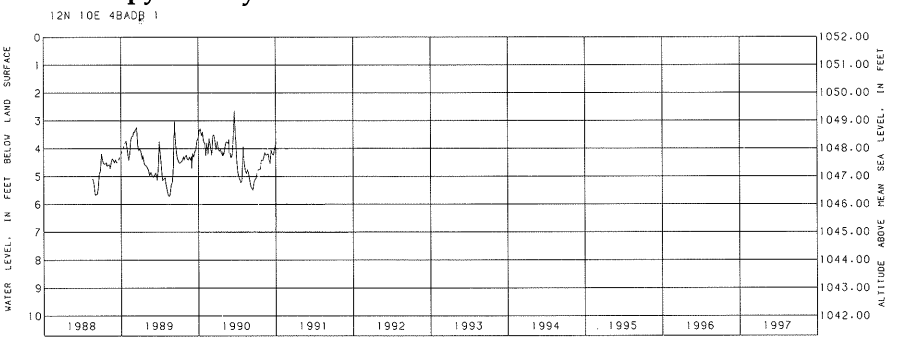


Pierce County: Osmond Recorder Well



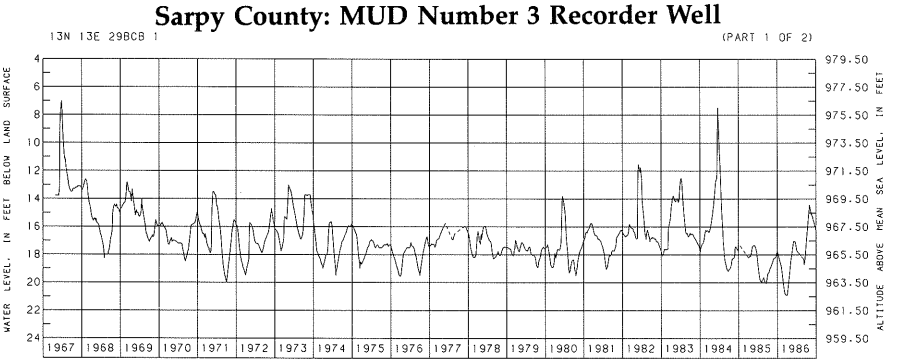
Sarpy County: Lincoln Well Field M90-33R Recorder Well

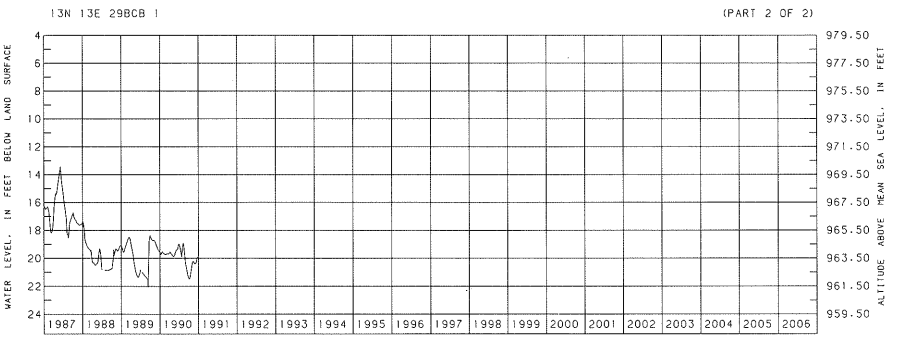
Estimated predevelopment water level: 3.5 feet
Net water-level change in 1990: -0.25 foot
Net water-level change since 1988: +0.56 foot



Sarpy County: MUD Number 3 Recorder Well

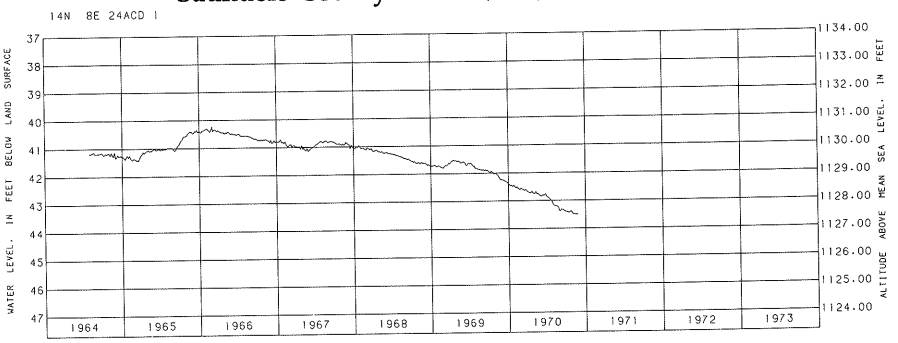
Estimated predevelopment water level: 13 feet
Net water-level change in 1990: -0.31 foot
Net water-level change since 1967: -6.60 feet





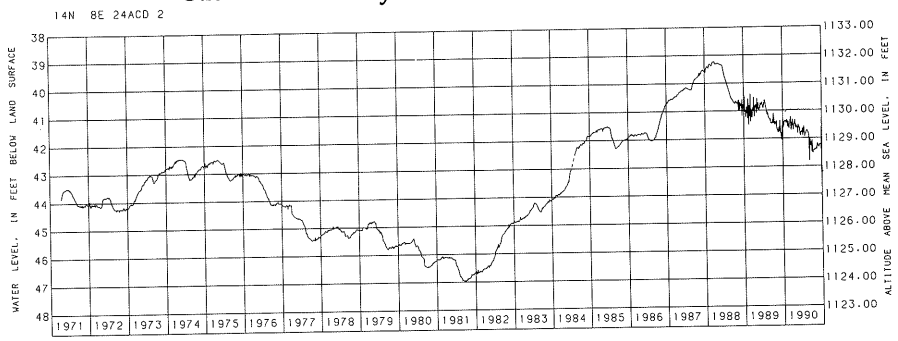
Saunders County: Mead (Old) Recorder Well

Estimated predevelopment
water level: 40 feet
Well abandoned in 1970
Net water-level change
from 1964 to 1970:
- 1.99 feet



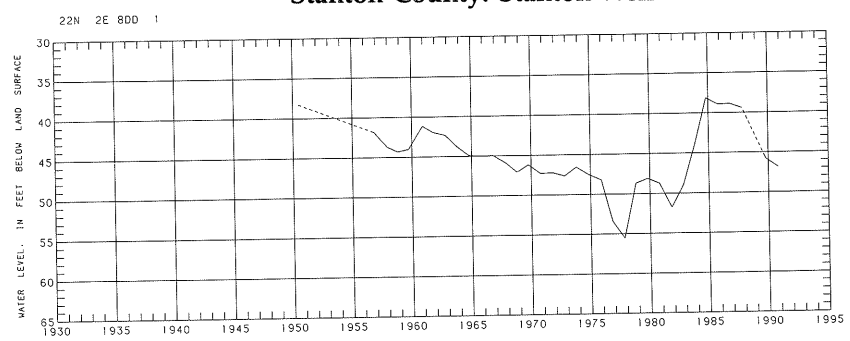
Saunders County: Mead (New) Recorder Well

Estimated predevelopment
water level: 40 feet
Net water-level change in
1990: -0.59 foot
Net water-level change
since 1971: +1.84 feet



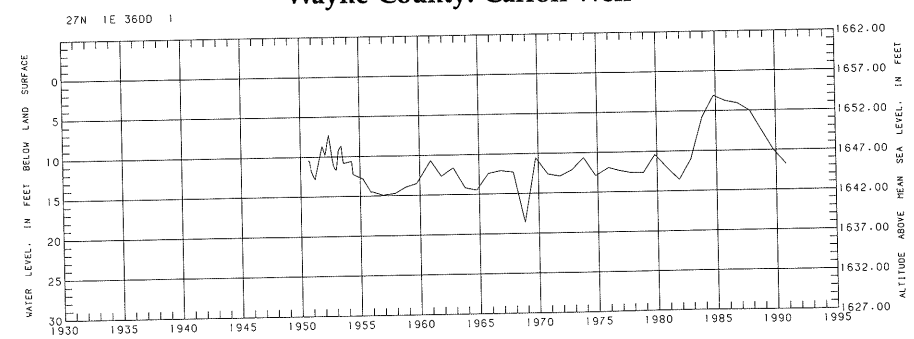
Stanton County: Stanton Well

Measured annually
Estimated predevelopment
water level: 38 feet
Net water-level change,
fall 1989 to fall 1990:
-1.05 feet
Net water-level change
since 1950: -8.72 feet



Wayne County: Carroll Well

Measured annually
Estimated predevelopment
water level: 10.6 feet
Net water-level change,
fall 1989 to fall 1990:
-2.31 feet
Net water-level change
since 1950: -0.73 foot



In the East South-Central Division 85 percent of the water levels measured in the spring of 1990 were lower than those measured in the spring of 1989.

East South-Central Division

In the East South-Central Division, 85 percent of the groundwater levels measured in 888 observation wells were lower in the spring of 1990 than they were in the spring of 1989. Most of the declines ranged from 1 to 2 feet, although declines from 2 to 10 feet were present. The declines are probably attributable to the less-than-normal precipitation during 1989 and during most of the 1989-1990 dormant season. Most fall 1990 water levels for the division ranged from 1 to 2 feet below fall 1989 levels for the south-southeastern parts and from 1 to 2 feet above fall 1989 levels for the north-northwestern parts. Part of Clay County had fall 1990 water-level rises almost 15 feet above fall 1989 water levels. Overall, the division had water levels that were 56 percent lower in fall 1990 than in fall 1989.

Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	888	85	-0.80
Fall	889	56	- .08

Pumping for irrigation during the past 40 years has caused water levels to decline at least 5 feet below the estimated predevelopment water levels in an area of about 1.48 million acres. During 1989 and 1990 a maximum decline of 42 feet occurred in two wells located in Fillmore County. Approximate areas of significant declines from estimated predevelopment water levels to fall 1990 water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	518,000
10-15	504,000
15-20	246,000
20-25	177,000
25-30	27,000
30 or more	9,800

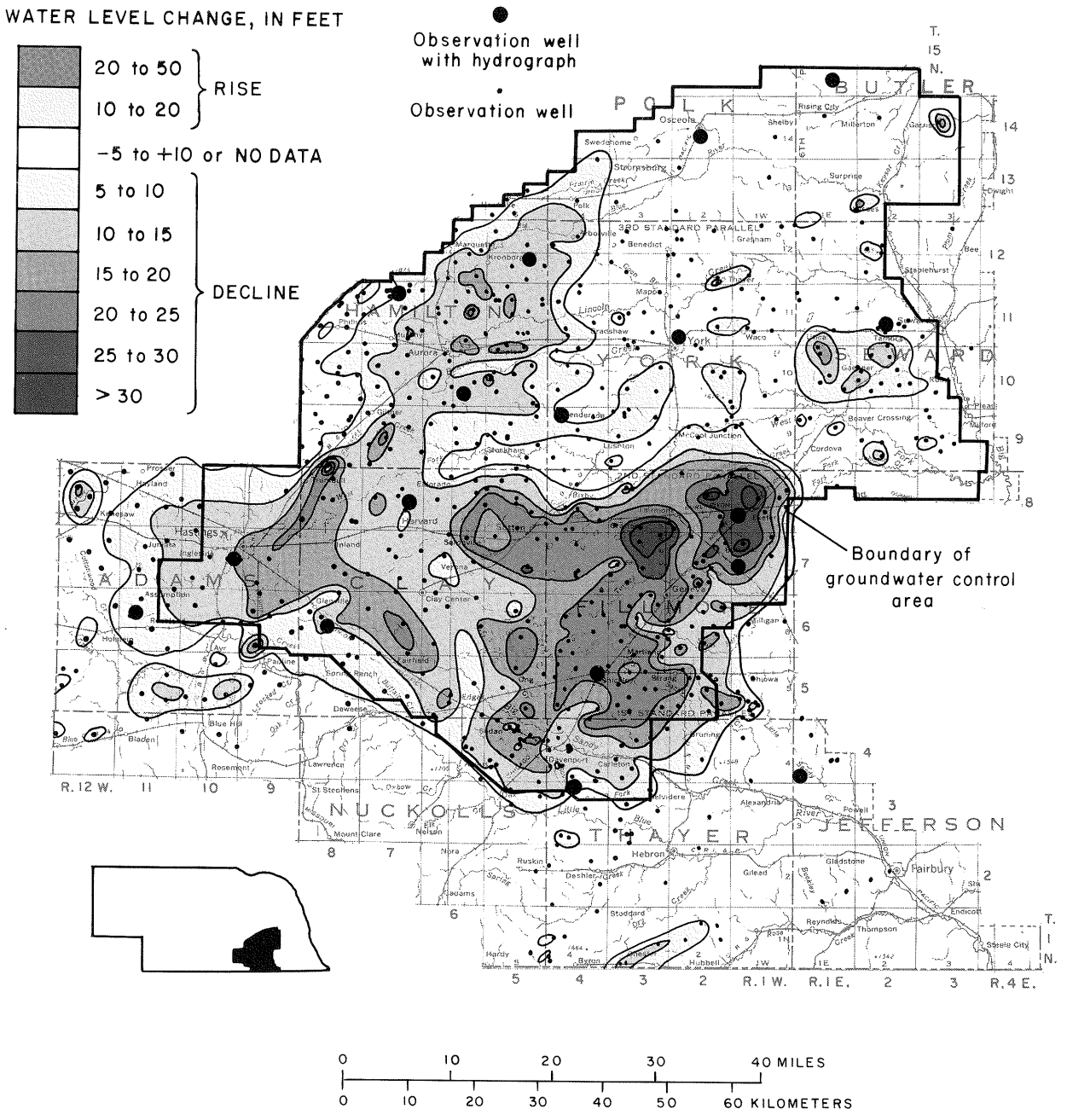
Sufficient data are available to provide reasonable definition of estimated predevelopment water levels throughout most of the division. Data collected by the Blue River Association of Ground Water Conservation Districts, the Clay County Ground Water Conservation District, and the Upper Big Blue and Little Blue natural resources districts are sufficient to evaluate current water-level changes.

In this division, estimated predevelopment water levels are representative of the approximate average water levels prior to 1950. Although about 700 irrigation wells had been drilled prior to 1950, they were widely distributed, and significant water-level declines had occurred in only a few small localities. Widespread development of groundwater for irrigation occurred between 1953 and 1956 because of drought conditions, and by 1957 about 6,400 irrigation wells had been drilled. By the end of 1990, there were about 15,600 registered irrigation wells in the division. Irrigation wells have been drilled in almost all parts of this division where groundwater supplies are adequate and where development is not limited by other factors such as land use, soil type, or topography.

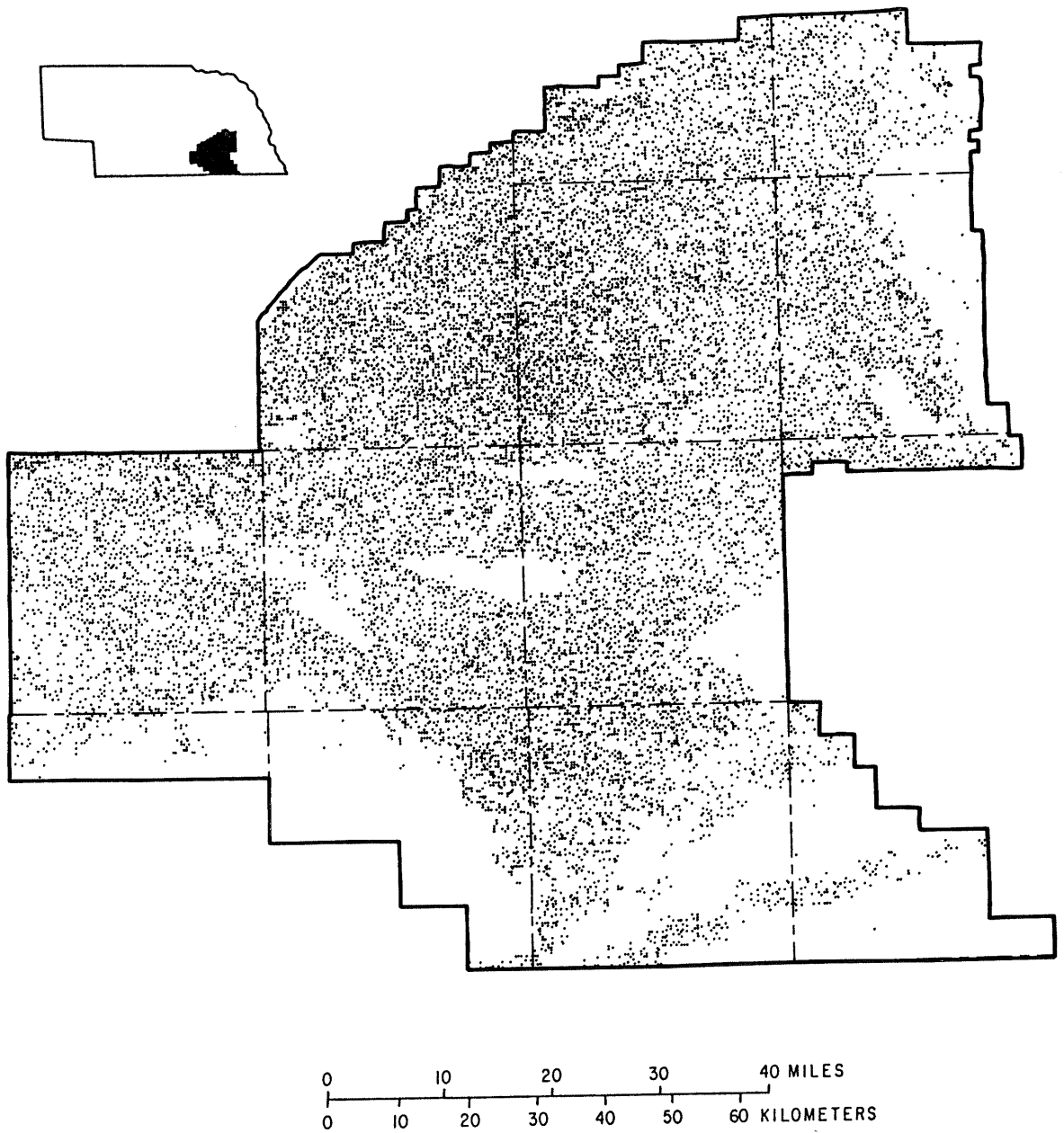
Because the Upper Big Blue and Little Blue groundwater control areas are in this division, information on water-level changes from estimated predevelopment levels to the spring of 1990 also is provided. The spring 1990 water levels declined at least 5 feet from estimated predevelopment levels in areas totaling about 1.26 million acres.

Approximate areas of significant declines from estimated predevelopment to spring 1990 water levels were:

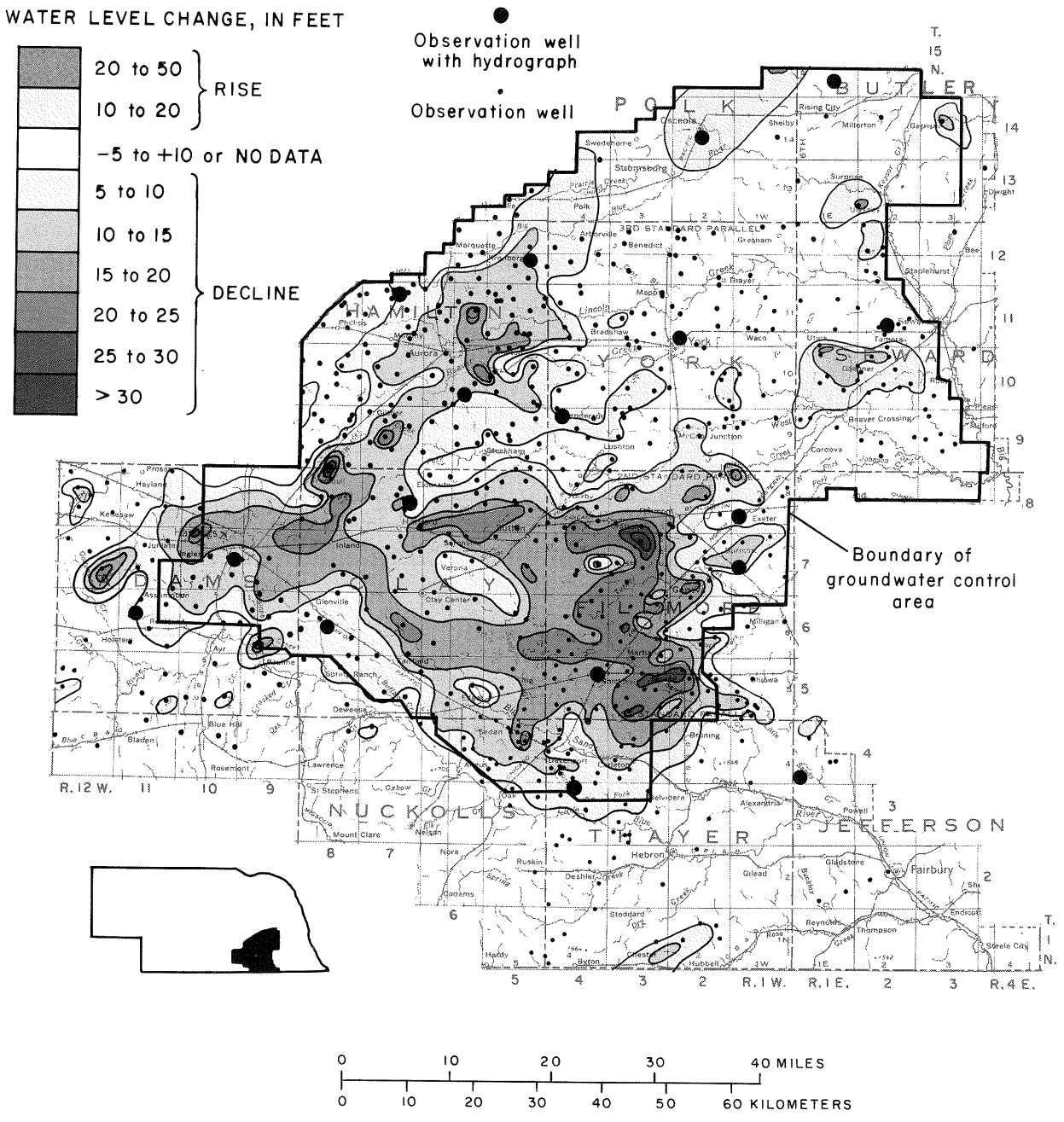
Range of decline, in feet	Approximate area of decline, in acres
5-10	514,000
10-15	367,000
15-20	270,000
20-25	101,000
25-30	10,900
30 or more	1,300



Areas of significant water-level change in the East South-Central Division from 1950 to fall 1990



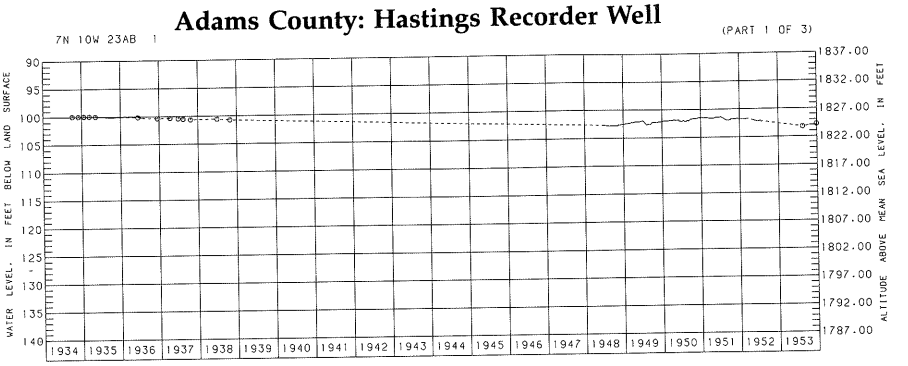
Location of registered irrigation wells in the East South-Central Division as of December 31, 1990

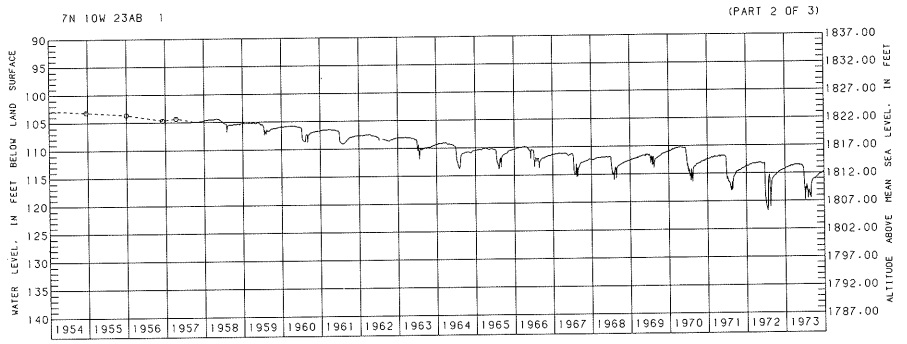


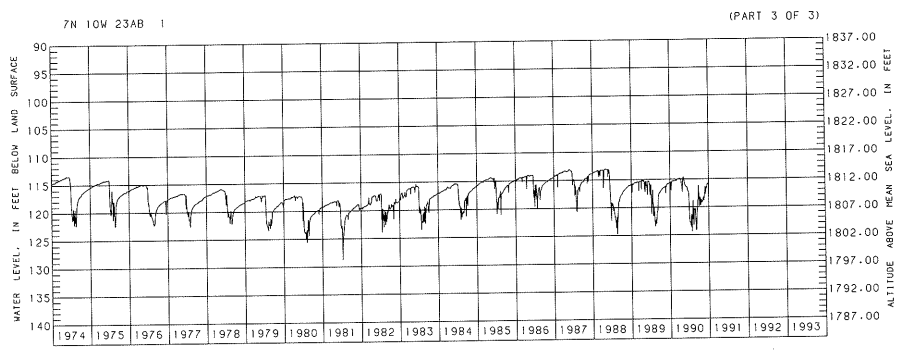
Areas of significant water-level change in the East South-Central Division from 1950 to spring 1990

Adams County: Hastings Recorder Well

Estimated predevelopment water level: 102 feet
Net water-level change in 1990: -0.23 foot
Net water-level change since 1934: -15.79 feet

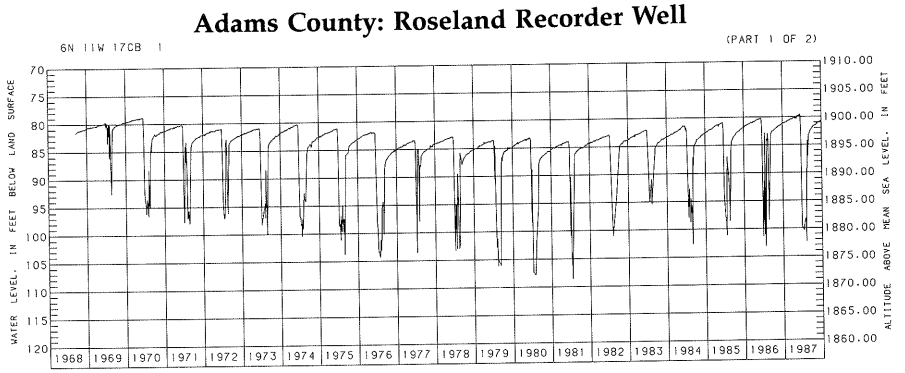




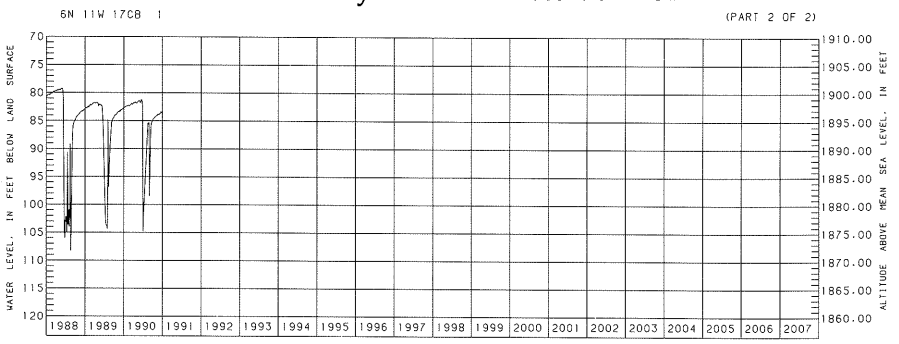


Adams County: Roseland Recorder Well

Estimated predevelopment water level: 77 feet
Net water-level change in 1990: -0.79 foot
Net water-level change since 1968: -2.76 feet

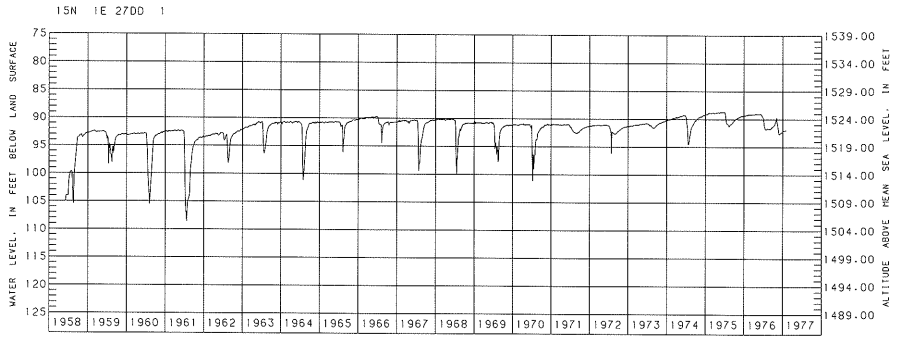


Adams County: Roseland Recorder Well



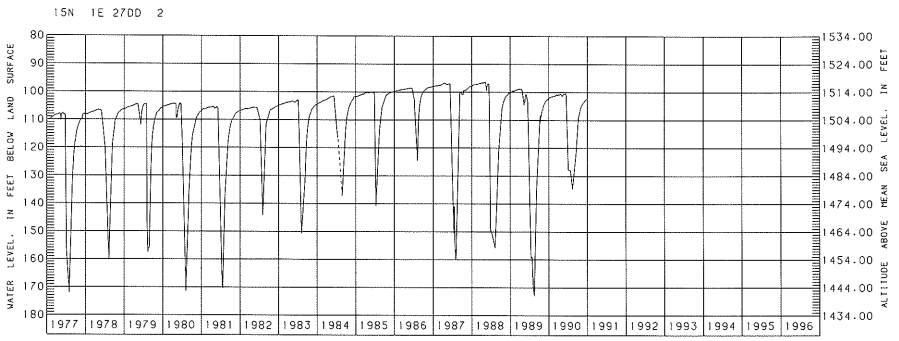
Butler County: Rising City (Old) Recorder Well

Estimated predevelopment water level: 108 feet
Well abandoned in 1977
Net water-level change from 1958 to 1976: +0.62 foot



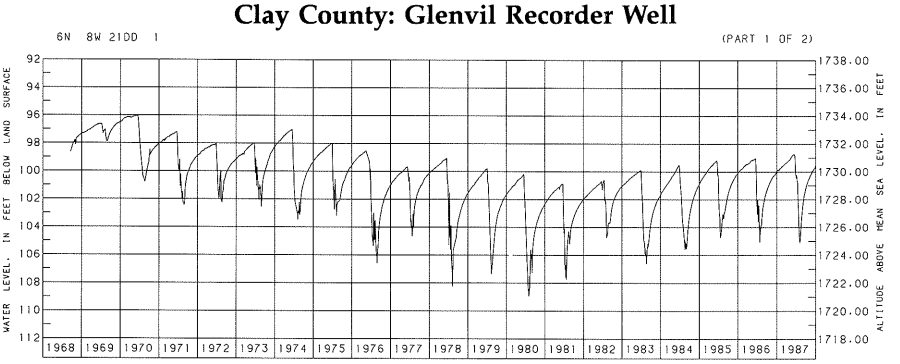
Butler County: Rising City (New) Recorder Well

Estimated predevelopment water level: 108 feet
Net water-level change in 1990: -0.34 foot
Net water-level change since 1977: +5.47 feet

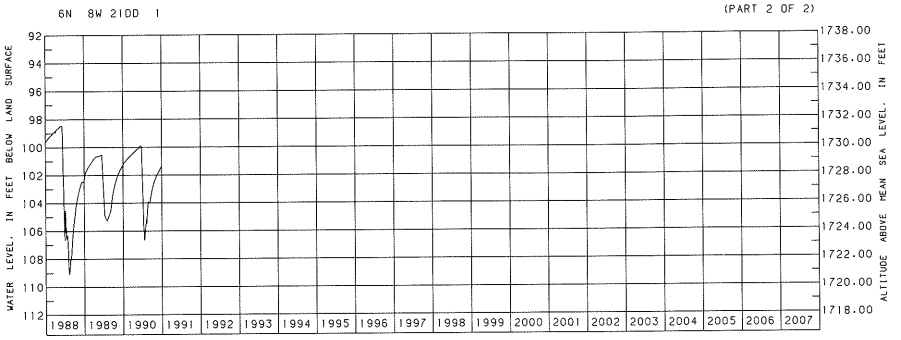


Clay County: Glenvil Recorder Well

Estimated predevelopment water level: 93 feet
Net water-level change in 1990: -0.12 foot
Net water-level change since 1968: -4.04 feet

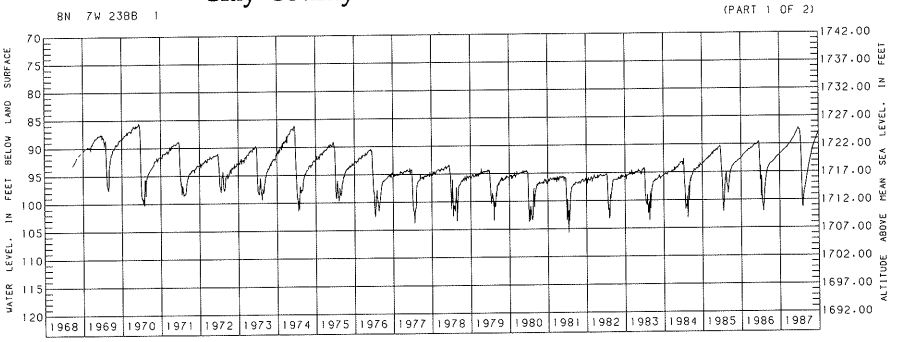


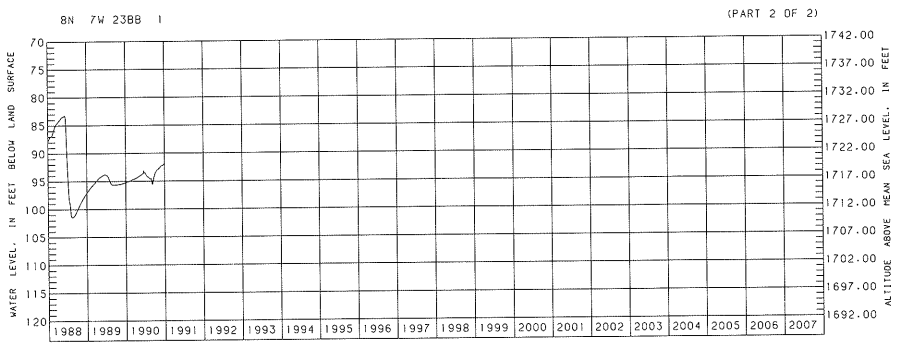
Clay County: Glenvil Recorder Well



Clay County: Harvard Recorder Well

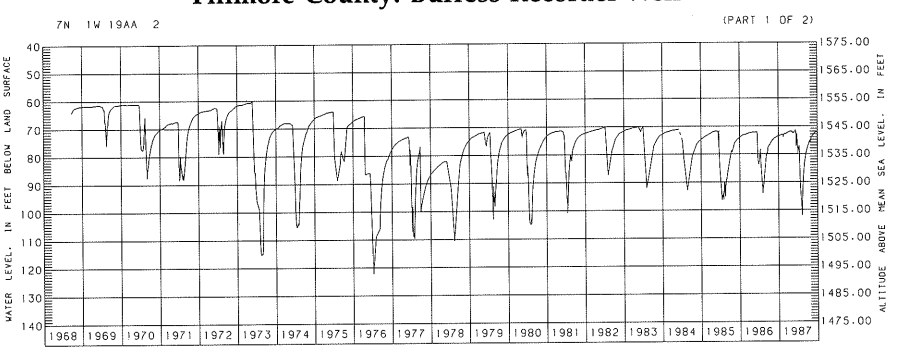
Estimated predevelopment water level: 79 feet
Net water-level change in 1990: +3.29 feet
Net water-level change since 1968: -1.43 feet



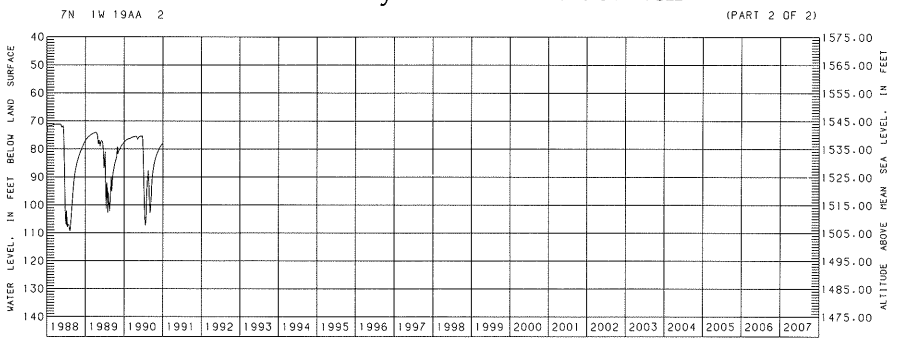


Fillmore County: Burress Recorder Well

Estimated predevelopment water level: 57 feet
Net water-level change in 1990: -0.52 foot
Net water-level change since 1968: -16.09 feet

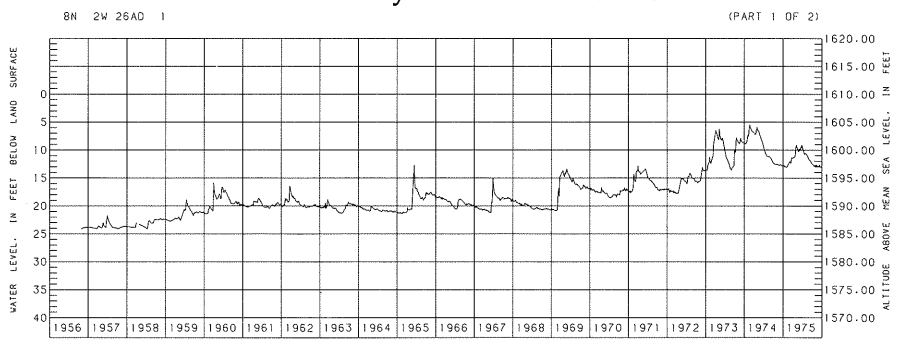


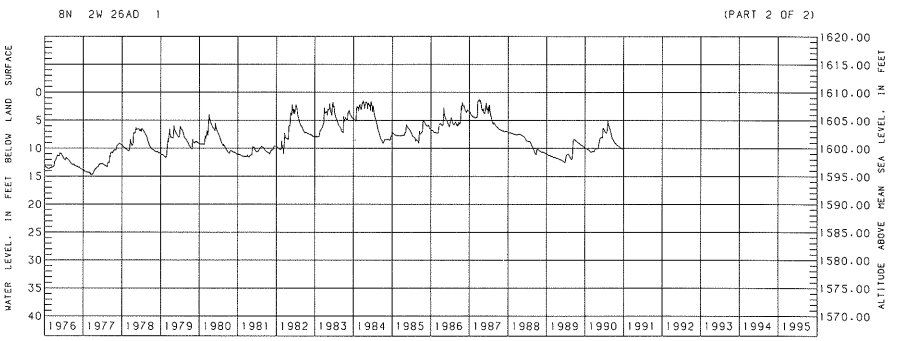
Fillmore County: Burress Recorder Well



Fillmore County: Exeter Recorder Well

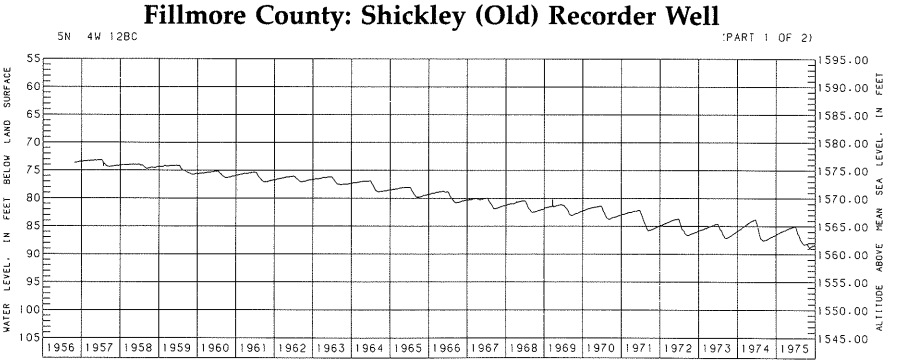
Estimated predevelopment water level: 24 feet
Net water-level change in 1990: -0.42 foot
Net water-level change since 1956: +13.59 feet



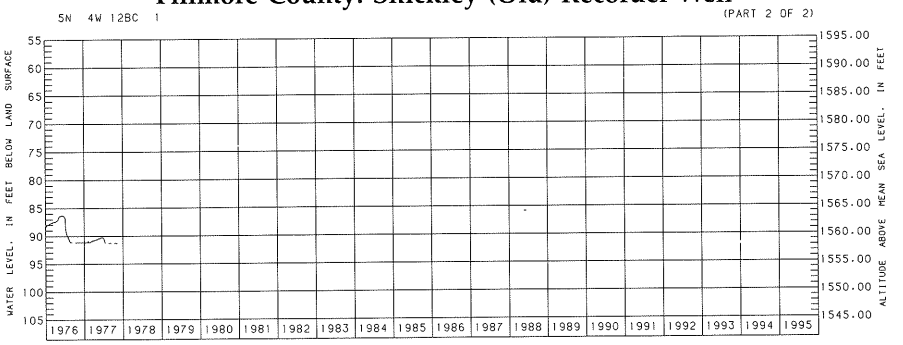


Fillmore County: Shickley (Old) Recorder Well

Estimated predevelopment water level: 73 feet
Well abandoned in 1977
Net water-level change from 1956 to 1976: -14.83 feet

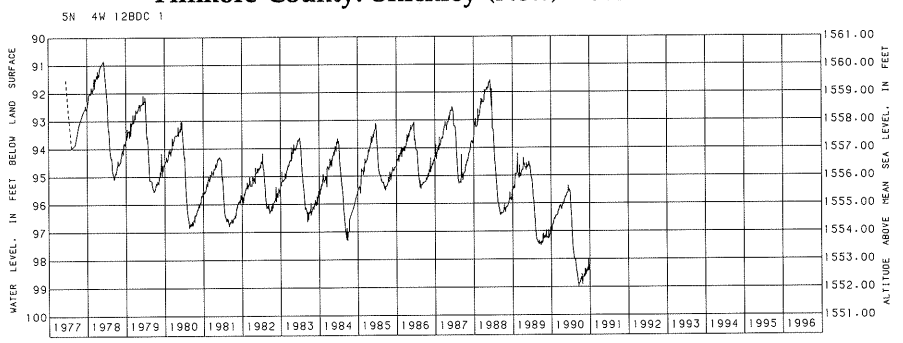


Fillmore County: Shickley (Old) Recorder Well



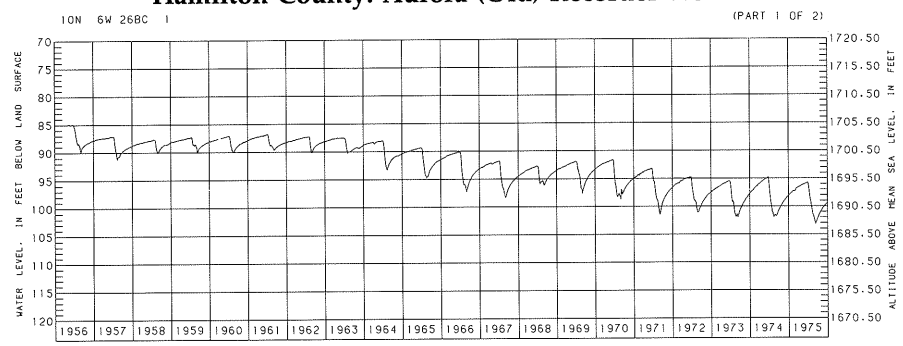
Fillmore County: Shickley (New) Recorder Well

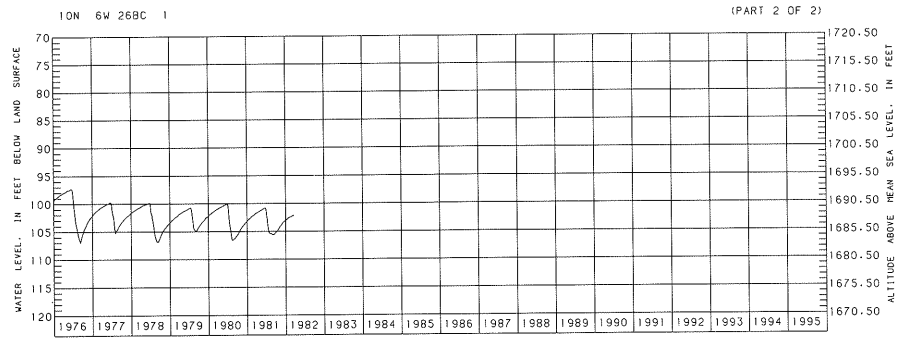
Estimated predevelopment water level: 72 feet
Net water-level change in 1990: -1.31 feet
Net water-level change since 1977: -5.65 feet



Hamilton County: Aurora (Old) Recorder Well

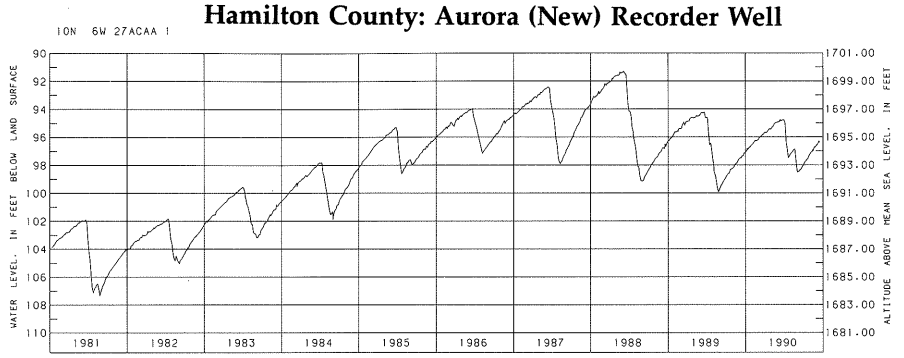
Estimated predevelopment water level: 83 feet
Well abandoned in 1981
Net water-level change from 1956 to 1981: -15.20 feet





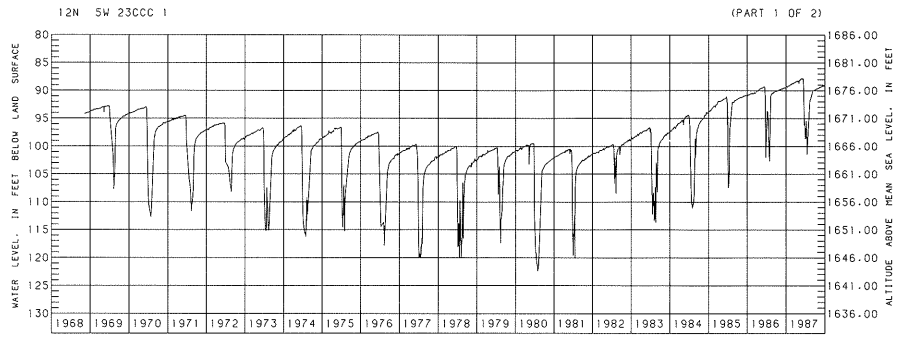
Hamilton County: Aurora (New) Recorder Well

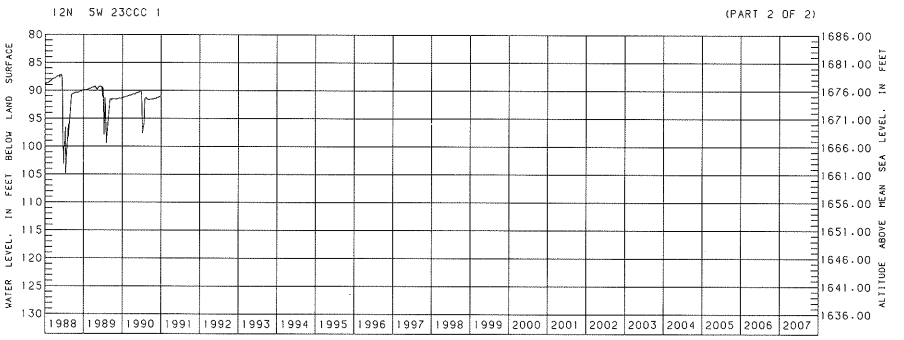
Estimated predevelopment water level: 84 feet
Net water-level change in 1990: +0.72 foot
Net water-level change since 1980: +7.73 feet



Hamilton County: Kronborg Recorder Well

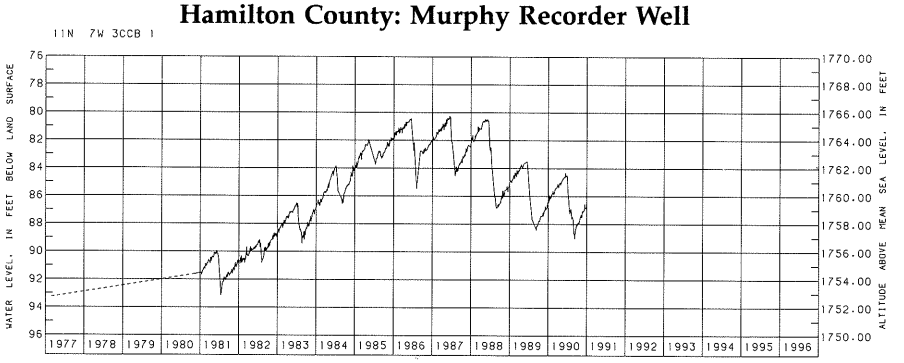
Estimated predevelopment water level: 81 feet
Net water-level change in 1990: +0.30 foot
Net water-level change since 1968: +2.85 feet





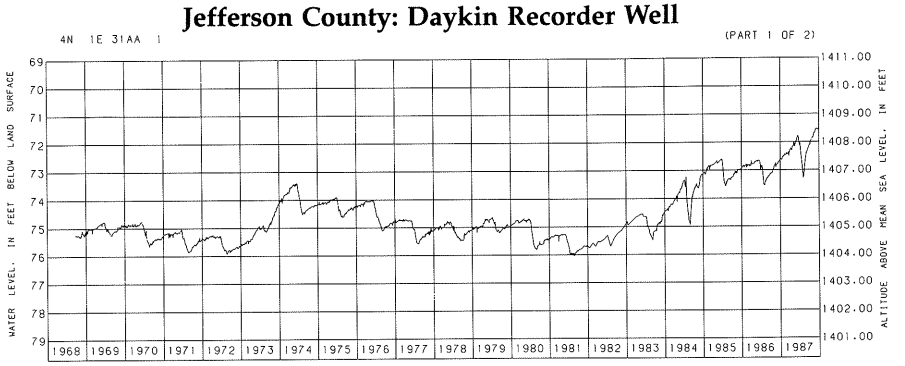
Hamilton County: Murphy Recorder Well

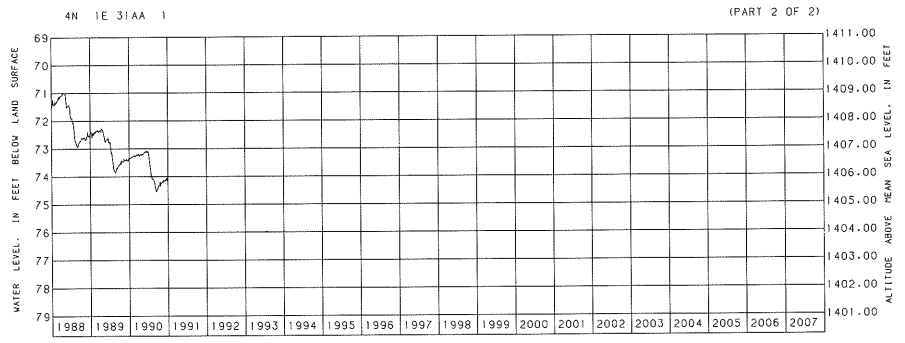
Estimated predevelopment water level: 83 feet
Net water-level change in 1990: -0.11 foot
Net water-level change since 1977: +6.69 feet



Jefferson County: Daykin Recorder Well

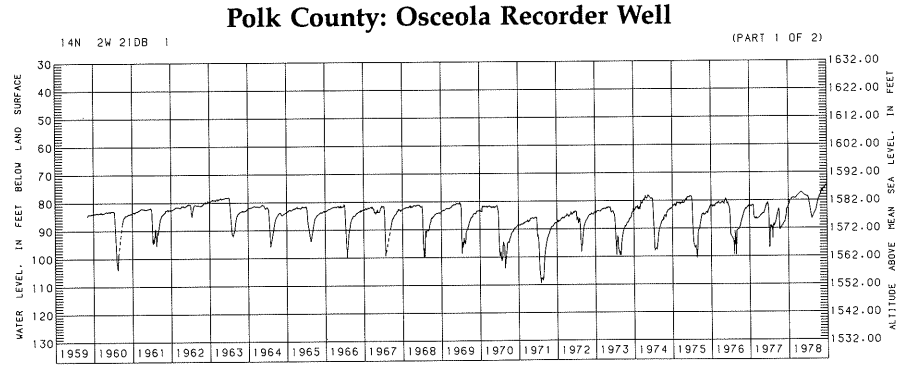
Estimated predevelopment water level: 74 feet
Net water-level change in 1990: -0.70 foot
Net water-level change since 1968: +1.19 feet

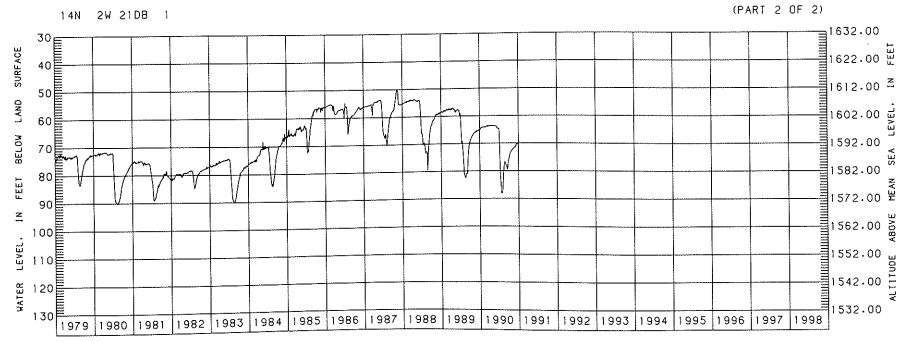




Polk County: Osceola Recorder Well

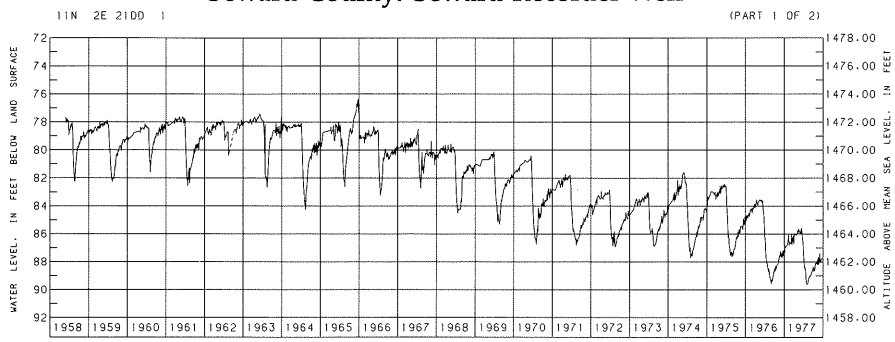
Estimated predevelopment water level: 80 feet
Net water-level change in 1990: -6.11 feet
Net water-level change since 1959: +12.88 feet
Lower part of casing may have collapsed.

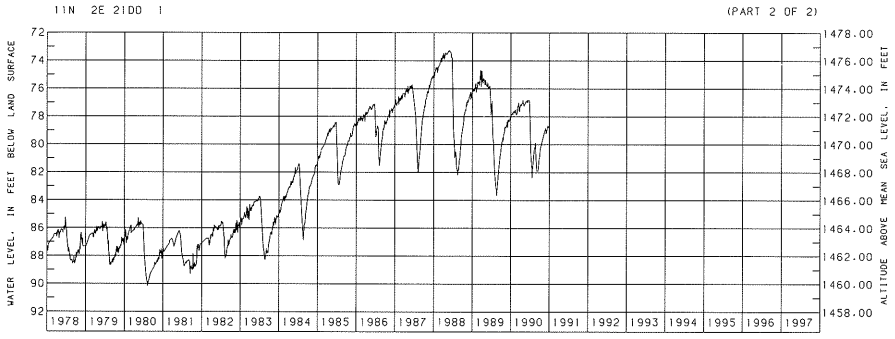




Seward County: Seward Recorder Well

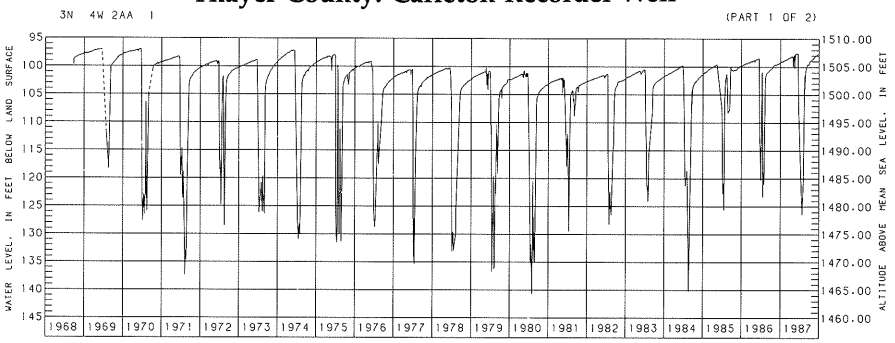
Estimated predevelopment water level: 74 feet
Net water-level change in 1990: -0.80 foot
Net water-level change since 1958: -0.02 foot

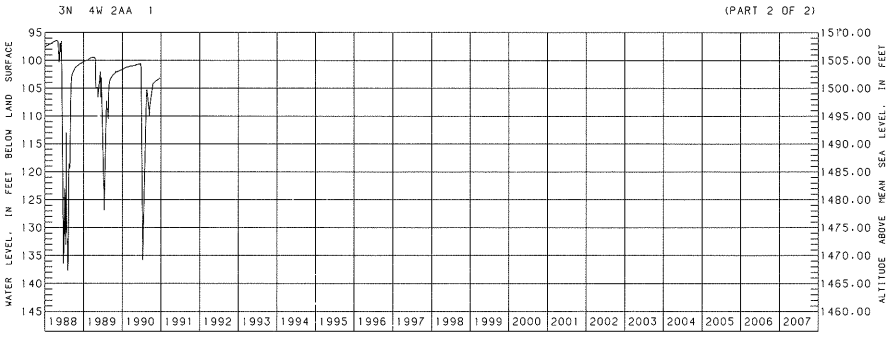




Thayer County: Carleton Recorder Well

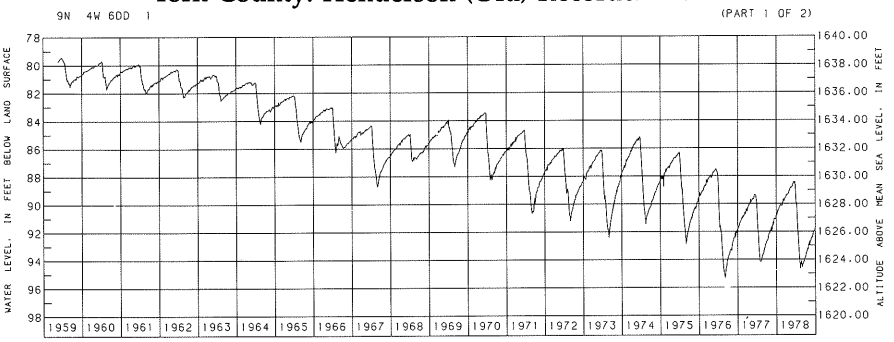
Estimated predevelopment water level: 95 feet
Net water-level change in 1990: -1.65 feet
Net water-level change since 1968: -5.35 feet

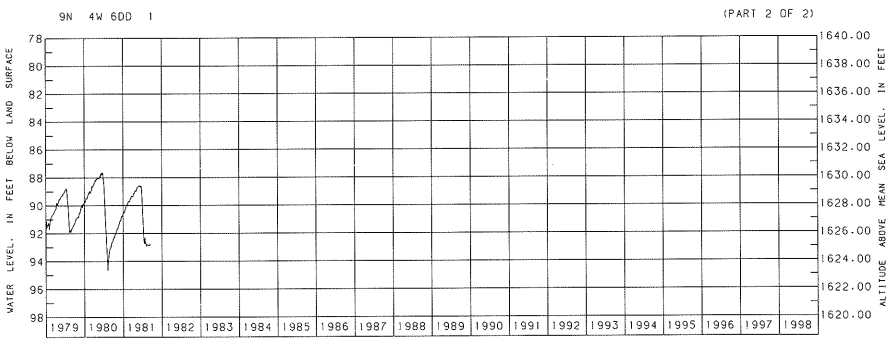




York County: Henderson (Old) Recorder Well

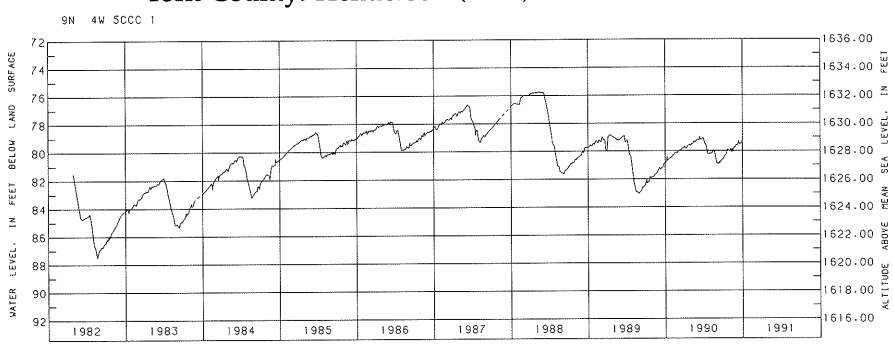
Estimated predevelopment water level: 80 feet
Well destroyed in 1981
Net water-level change from 1959 to 1981: -10.02 feet





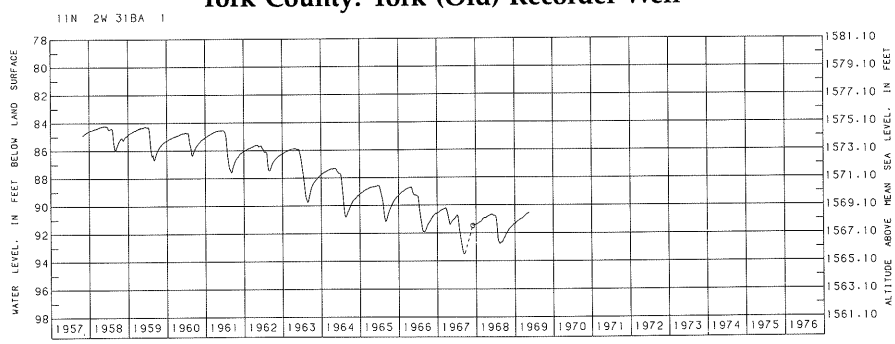
York County: Henderson (New) Recorder Well

Estimated predevelopment water level: 70 feet
Net water-level change in 1990: +1.66 feet
Net water-level change since 1982: +4.93 feet



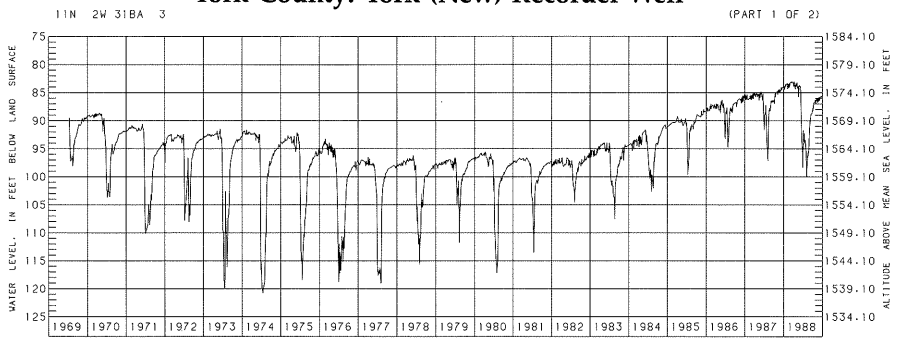
York County: York (Old) Recorder Well

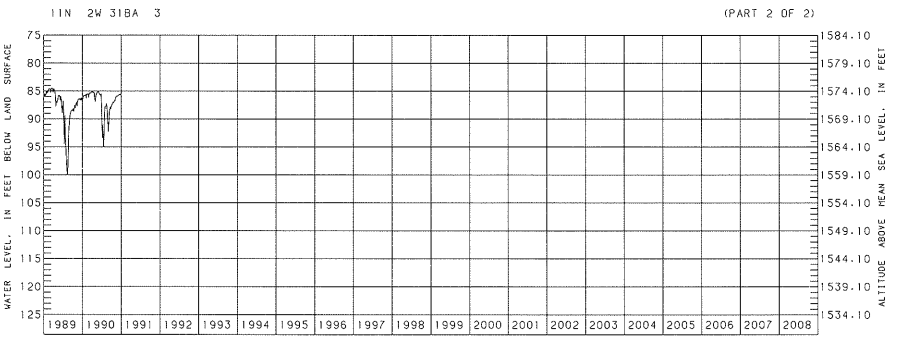
Estimated predevelopment water level: 84 feet
Well abandoned in 1969
Net water-level change from 1957 to 1968: -6.78 feet



York County: York (New) Recorder Well

Estimated predevelopment water level: 85 feet
Net water-level change in 1990: +0.82 foot
Net water-level change since 1969: +3.58 feet





Water levels in most observation wells in the West South-Central Division were slightly lower in the fall of 1990 than they were in the fall of 1989.

West South-Central Division

In the West South-Central Division, groundwater levels during the spring of 1990 generally were higher than during the spring of 1989. Water levels in 62 percent of the 264 observation wells were higher than water levels during spring 1989, with an average rise of 0.32 foot. During the fall of 1990, water levels in 67 percent of the 310 observation wells were lower than water levels in 1989. Most water-level changes were between 1 foot higher and 1 foot lower than in the fall of 1989. Areas of declines greater than 1 foot in Phelps and Kearney counties increased considerably from fall 1989 to fall 1990. These declines probably were the result of about 30 percent less-than-normal precipitation during the months of June and July.

Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	264	38	0.32
Fall	310	67	- .76

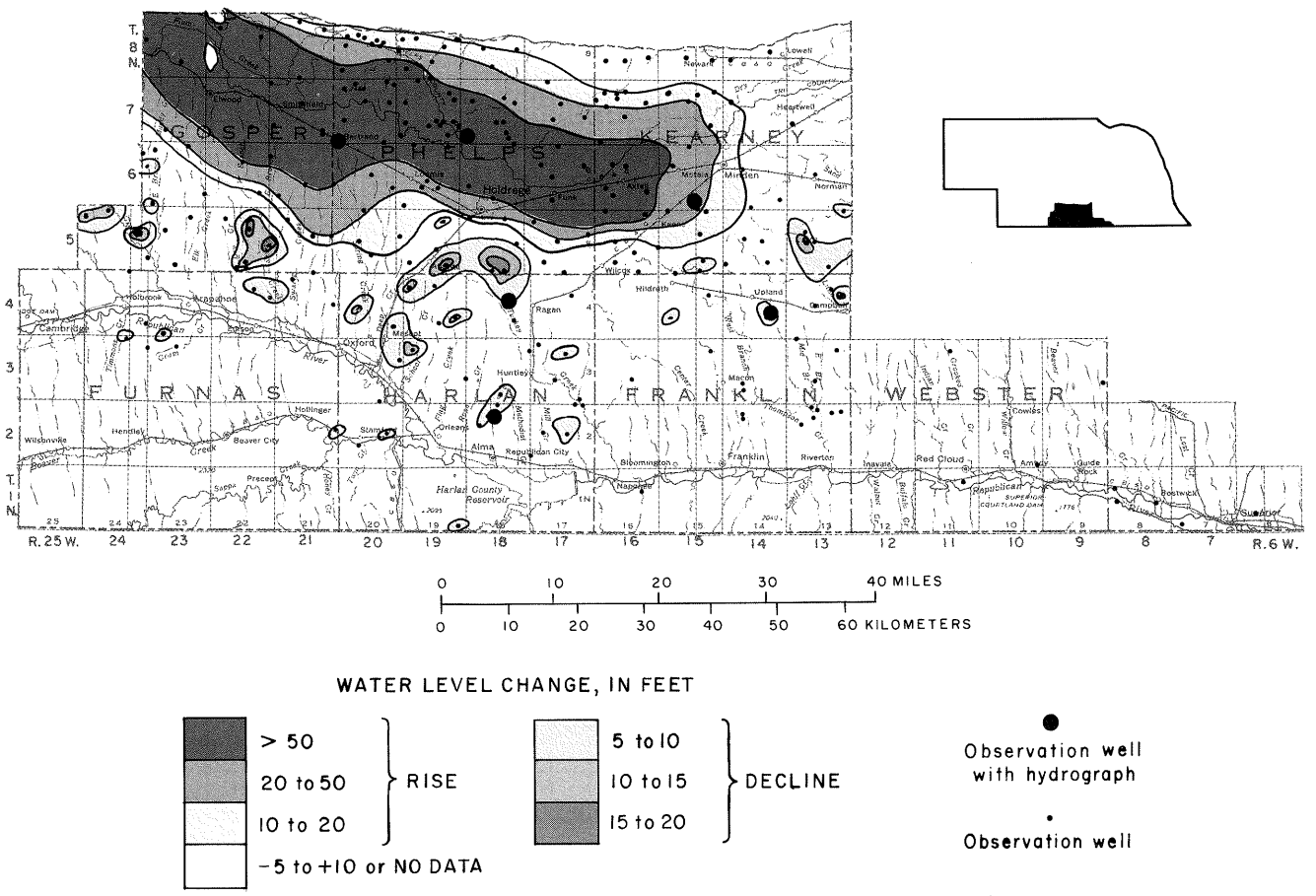
The water-level rise since predevelopment in Gosper, Kearney, and Phelps counties is the greatest in Nebraska. In this area, water released from storage in Lake McConaughy and subsequently diverted from the Platte River near North Platte has been used for irrigation since 1941. Deep percolation of water from the irrigation distribution systems and from water applied to crops has raised the water table 10 to 112 feet from its estimated predevelopment level beneath about 581,000 acres. The greatest known water-level rises from predevelopment are about 112 feet 6 miles north of Bertrand in Phelps County, about 101 feet 4.2 miles northwest of Elwood in Gosper County, and about 64 feet 1.1 miles north of Axtell in Kearney County. Estimated predevelopment water levels in Gosper, Kearney, and Phelps counties are about equal to average water levels just prior to 1940.

Approximate areas of significant water-level rises from estimated predevelopment to fall 1990 were:

Range of rise, in feet	Approximate area of rise, in acres
0-20	121,000
20-50	160,000
50 or more	300,000

In Gosper, Kearney, and Phelps counties, use of groundwater for irrigation has decreased the rate of water-level rise in many areas. Also, where the water table has risen enough, natural discharge through evapotranspiration and groundwater discharge into streams and wetlands contributes to stabilizing water levels. Elsewhere in the division, increased use of groundwater for irrigation in recent years has caused water levels to decline below estimated predevelopment levels in a number of small areas. Declines of at least 5 feet have occurred in areas totaling about 82,000 acres. At the end of 1990 there were about 6,800 registered irrigation wells in the division, 60 of which were drilled during 1990.

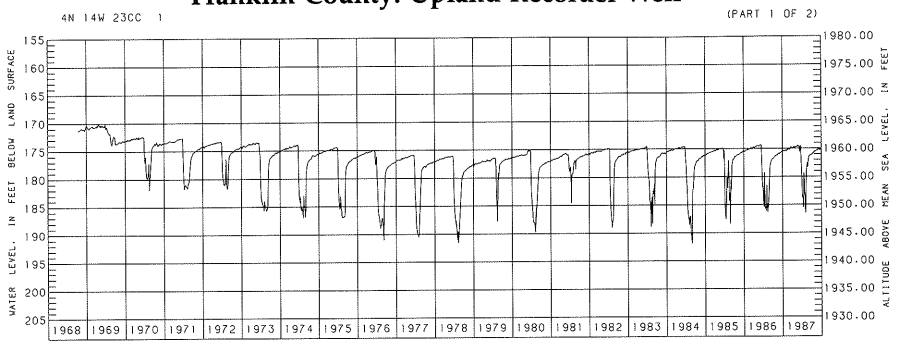
Data for estimating predevelopment water levels generally are adequate. Since 1947, water-level measurement programs have provided enough data for an adequate evaluation of long-term water-level changes and also for the definition of current water-level changes. Water-level data are collected by the Tri-Basin and Lower Republican natural resources districts, the Central Nebraska Public Power and Irrigation District, the Frenchman-Cambridge and Bostwick irrigation districts, the Harlan County and Furnas County extension agents, and the U.S. Geological Survey.

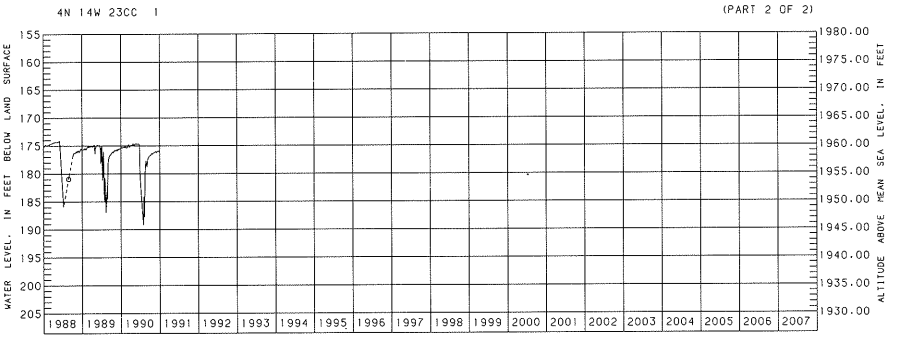


Areas of significant water-level change in the West South-Central Division from 1940 to fall 1990

Franklin County: Upland Recorder Well

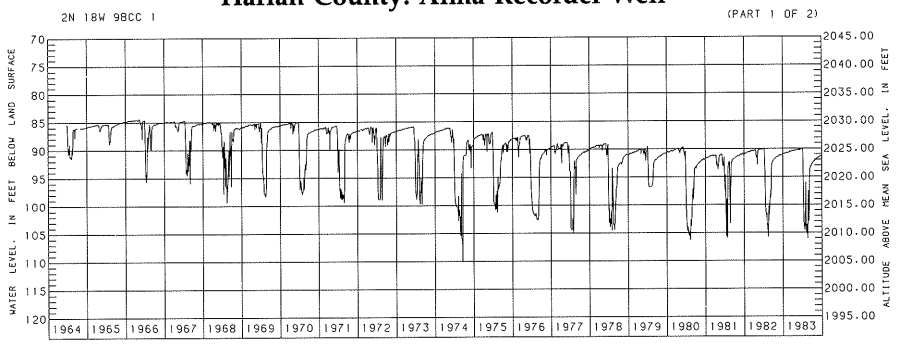
Estimated predevelopment water level: 170 feet
Net water-level change in 1990: -0.61 foot
Net water-level change since 1968: -5.59 feet

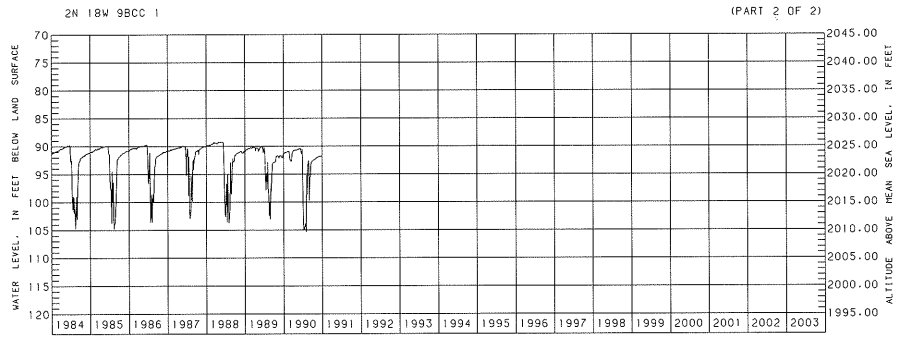




Harlan County: Alma Recorder Well

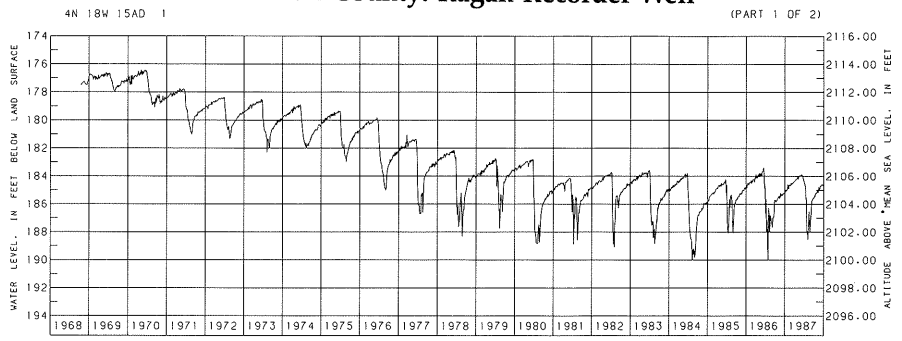
Estimated predevelopment water level: 85 feet
Net water-level change in 1990: -0.43 foot
Net water-level change since 1964: -5.73 feet

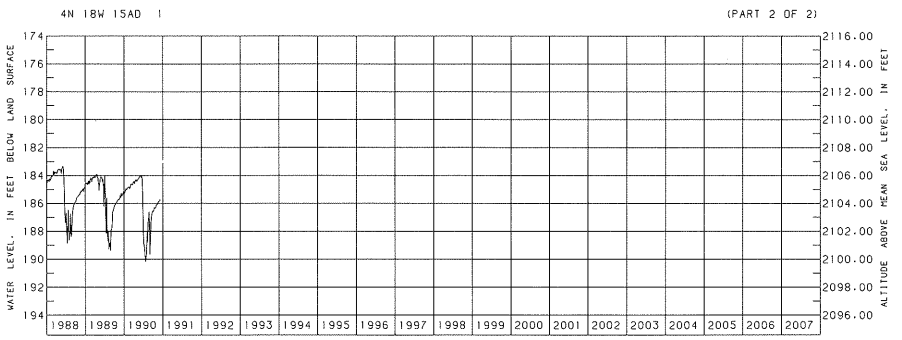




Harlan County: Ragan Recorder Well

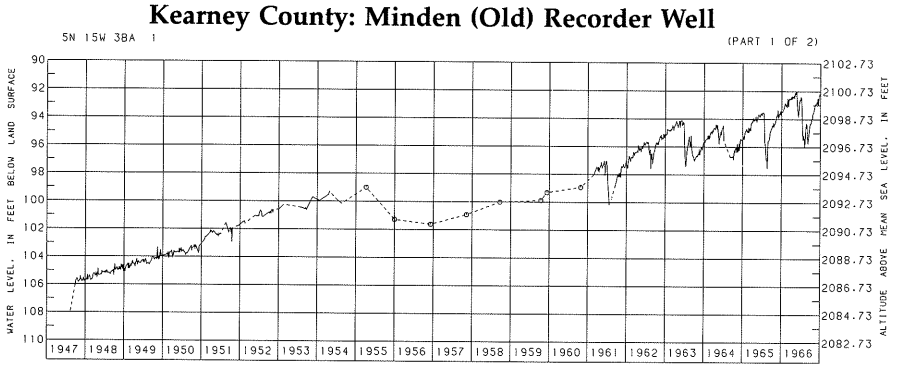
Estimated predevelopment water level: 176 feet
Net water-level change in 1990: -0.33 foot
Net water-level change since 1968: -8.54 feet

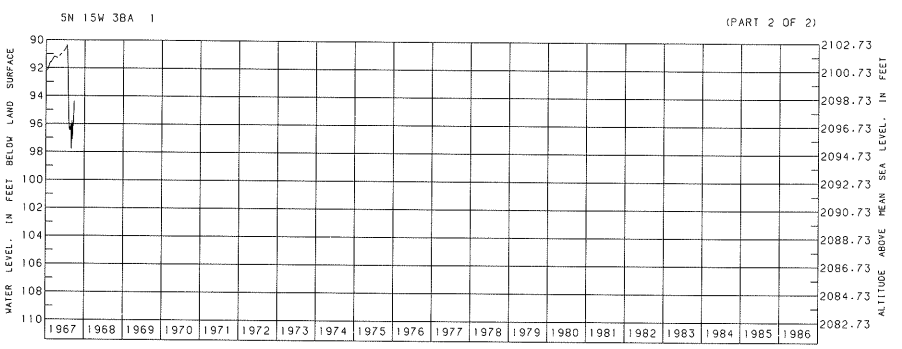




Kearney County: Minden (Old) Recorder Well

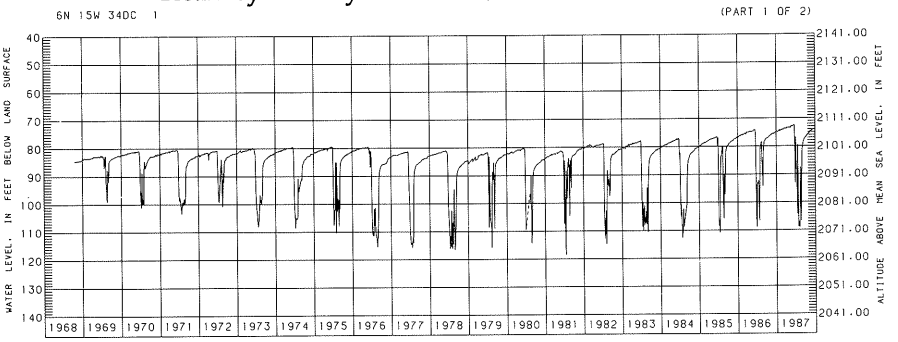
Estimated predevelopment water level: 113 feet
Well abandoned in 1967
Net water-level change from 1947 to 1966: +13.49 feet

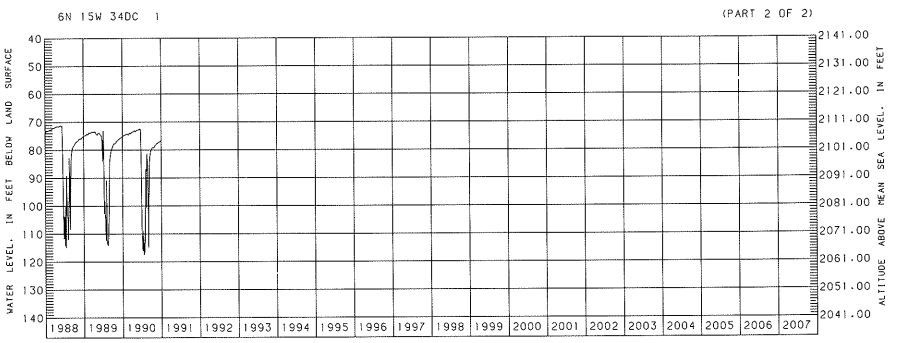




Kearney County: Minden (New) Recorder Well

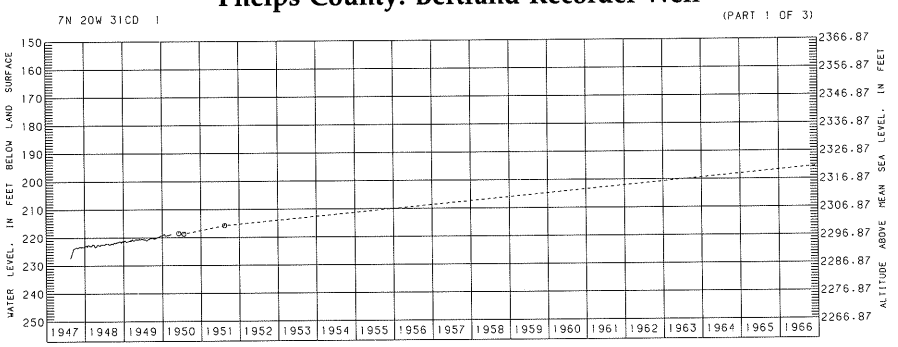
Estimated predevelopment water level: 103 feet
Net water-level change in 1990: -1.66 feet
Net water-level change since 1968: +7.17 feet

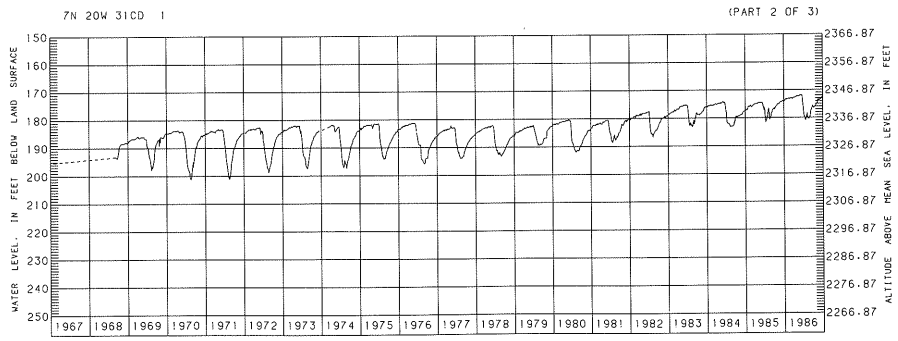




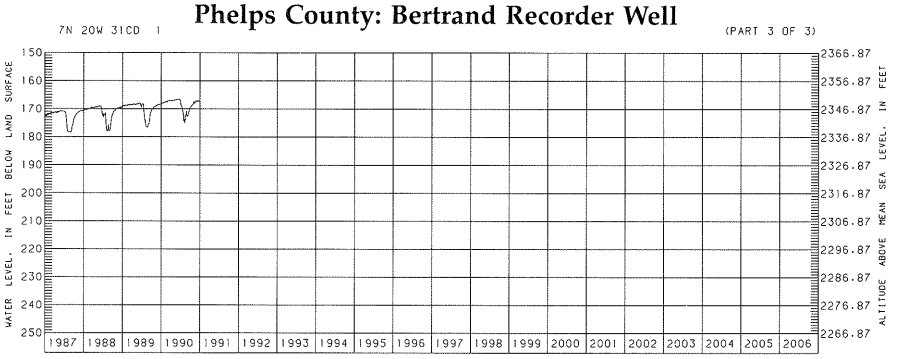
Phelps County: Bertrand Recorder Well

Estimated predevelopment water level: 232 feet
Net water-level change in 1990: +1.05 feet
Net water-level change since 1947: +56.10 feet



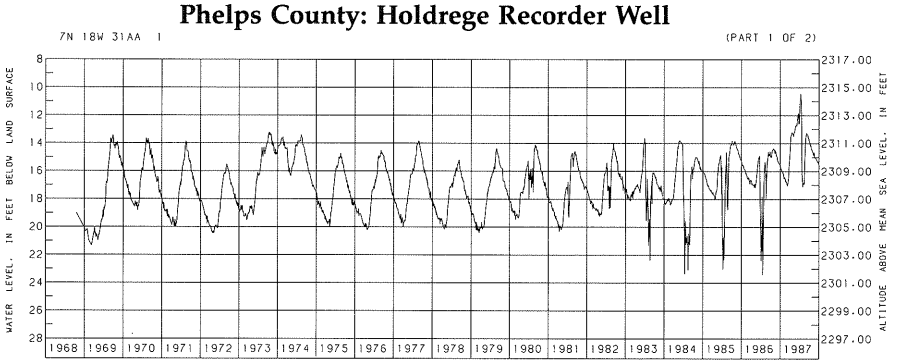


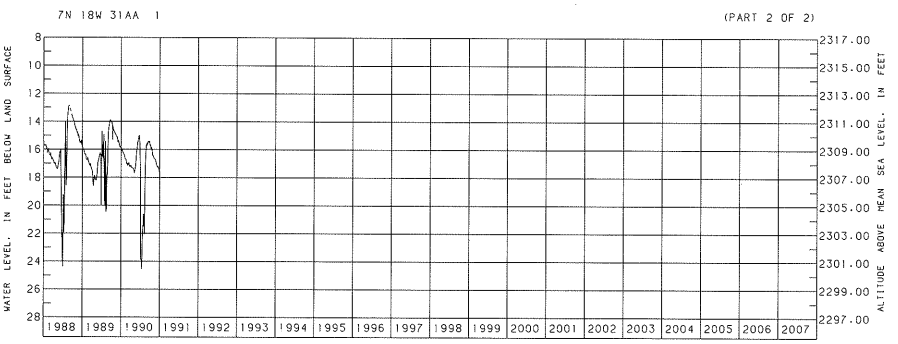
Phelps County: Bertrand Recorder Well



Phelps County: Holdrege Recorder Well

Estimated predevelopment water level: 100 feet
Net water-level change in 1990: -1.70 feet
Net water-level change since 1968: +2.43 feet





In the Central Division, many of the water levels along the Platte River valley were 1 to 3 feet lower in the fall of 1990 than they were in the fall of 1989.

Central Division

Groundwater levels in the Central Division generally were lower during 1990 than during 1989. However, water levels along the Platte River valley and in eastern Custer County generally were higher during the spring of 1990 than during the spring of 1989. Water levels in the eastern uplands of the division during the spring of 1990 were generally 1 to 2 feet lower than those during the spring of 1989. In the eastern part of the division, counties with the greatest declines from spring 1989 to spring 1990 were restricted mostly to Boone, Howard, and Platte, which showed only a few wells having declines of 5 to 10 feet from the spring of 1989. Parts of Merrick, Nance, and Wheeler counties also showed significant declines. The largest area of water-level declines of at least 2 feet from spring 1989 to spring 1990 occurred in Boone County. Scattered small areas of declines greater than 1 foot occurred in several other counties within the division. In the fall of 1990, 76 percent of the water levels measured in 872 wells were lower than in the fall of 1989. In the Platte River valley of Buffalo, Dawson, and Hall counties, water levels measured in the fall of 1990 were 1 to 3 feet lower than those in the fall of 1989. In northwestern Dawson County, fall 1990 water levels were 9 feet lower than those measured in the fall of 1989, and near Etna in southwestern Custer County, fall 1990 water levels were about 12 feet lower than those measured in fall of 1989.

Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	800	50	0.07
Fall	872	76	- .72

During the fall of 1990, declines of at least 5 feet from estimated predevelopment water levels occurred in an area of about 287,000 acres in Buffalo, Dawson, and Hall counties. Water levels were 25 to 35 feet lower than predevelopment levels in some wells in the uplands of southwestern Custer and northwestern Dawson counties, where use of groundwater for irrigation has resulted in large water-level declines during the past 3 years.

In Buffalo, Dawson, and Hall counties, approximate areas of significant water-level declines from estimated predevelopment water levels to fall 1990 water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	191,000
10-15	72,000
15-20	22,000
20-25	2,000

In the central part of Valley County, areas of decline of at least 5 feet from estimated predevelopment did not reappear in the fall of 1990. In those areas, recharge from precipitation and reduced irrigation probably accounted for the diminished declines. However, an area in Greeley County, just east of Valley County, had water-level declines of 5 to 10 feet from estimated predevelopment water levels.

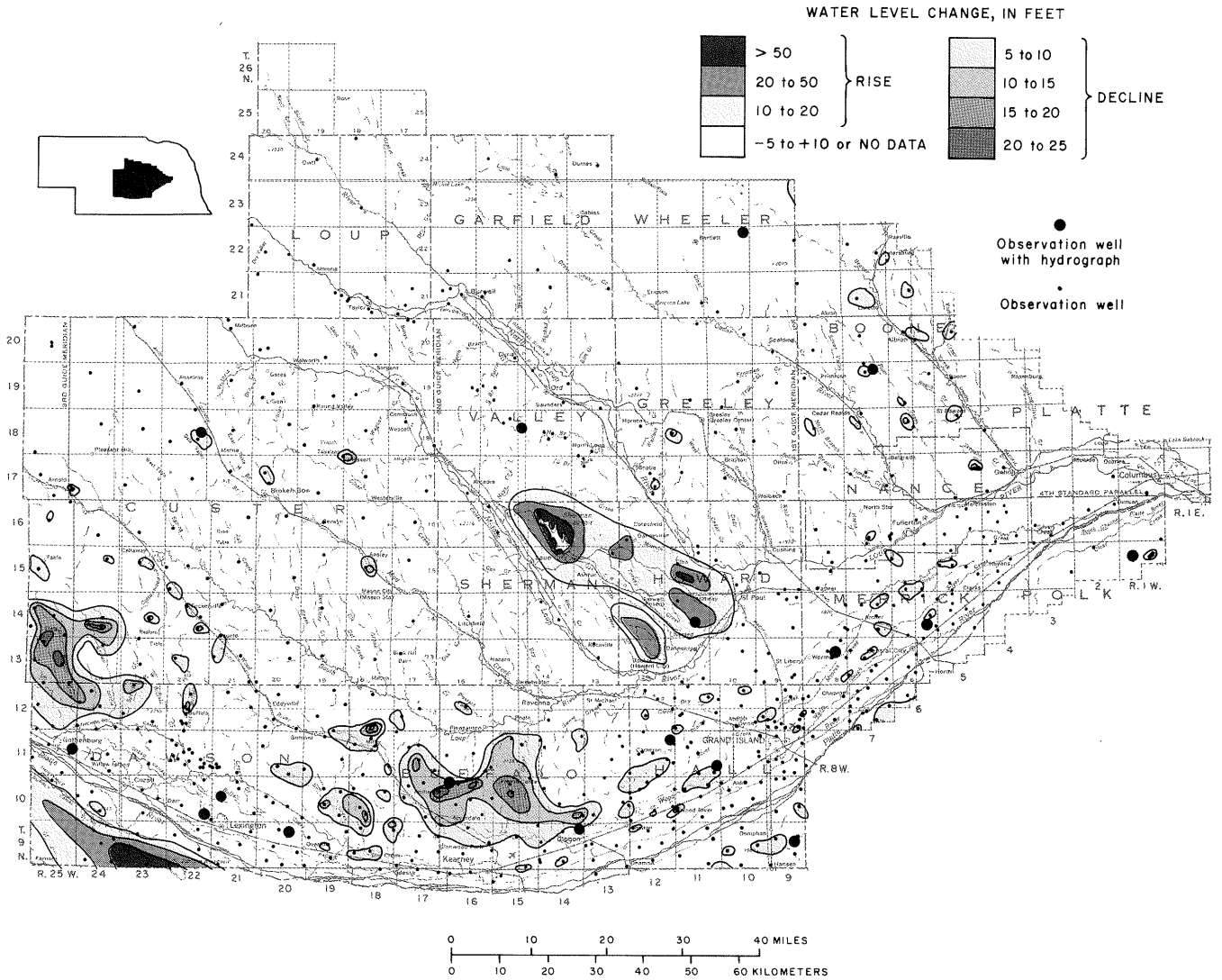
Water-level rises of 10 to 52 feet from estimated predevelopment levels have occurred beneath about 183,000 acres in the Farwell area of Howard and Sherman counties. The water-level rises in this area have resulted from water losses from irrigation canals, seepage from Sherman Reservoir, and deep percolation of irrigation water applied to crops. The greatest water-level rises, about 70 feet, were near Sherman Reservoir.

Approximate areas of significant rises from estimated predevelopment to fall 1990 water levels were:

Range of rise, in feet	Approximate area of rise, in acres
10-20	177,000
20-50	73,000
50 or more	19,000

At the end of 1990, there were about 22,300 registered irrigation wells in the division; 163 of these wells were drilled and registered during 1990.

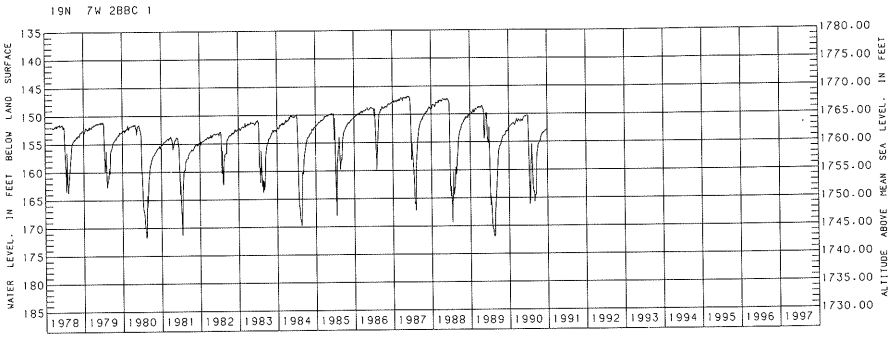
Data available for the Central Division provide a good basis for estimating predevelopment water levels, water-level changes since predevelopment, and current water-level changes. Water-level data are collected by the Central Platte and Lower Loup natural resources districts, the U.S. Bureau of Reclamation, and the U.S. Geological Survey.



Areas of significant water-level change in the Central Division from 1951 to fall 1990

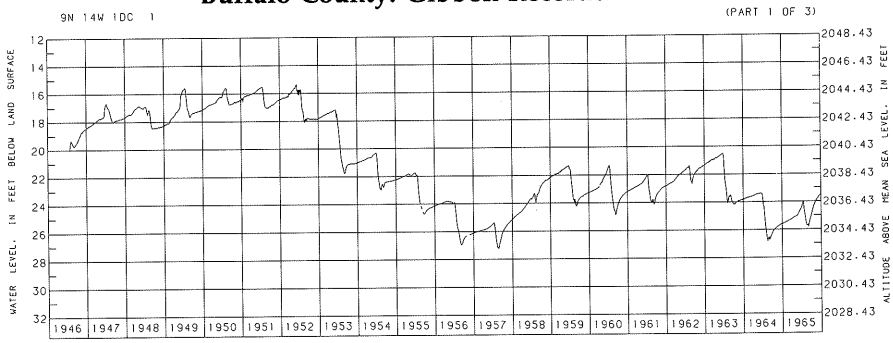
Boone County: Albion Recorder Well

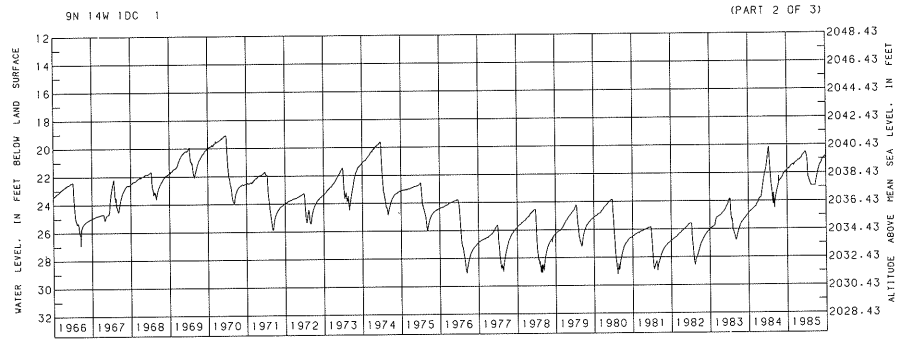
Estimated predevelopment water level: 150 feet
Net water-level change in 1990: -0.25 foot
Net water-level change since 1978: +0.20 foot

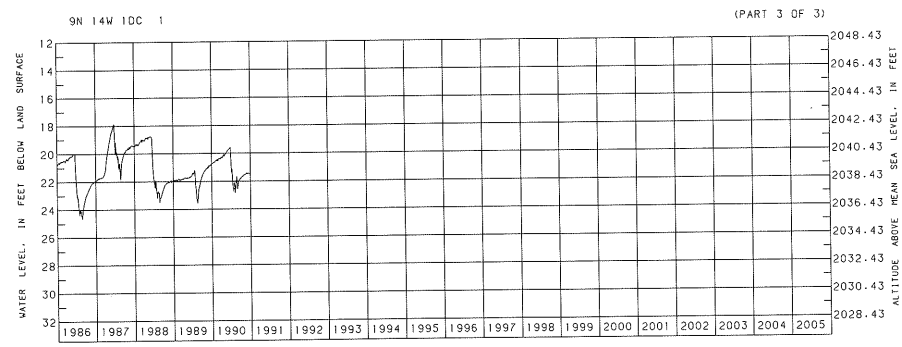


Buffalo County: Gibbon Recorder Well

Estimated predevelopment water level: 17 feet
Net water-level change in 1990: -0.65 foot
Net water-level change since 1946: -2.94 foot

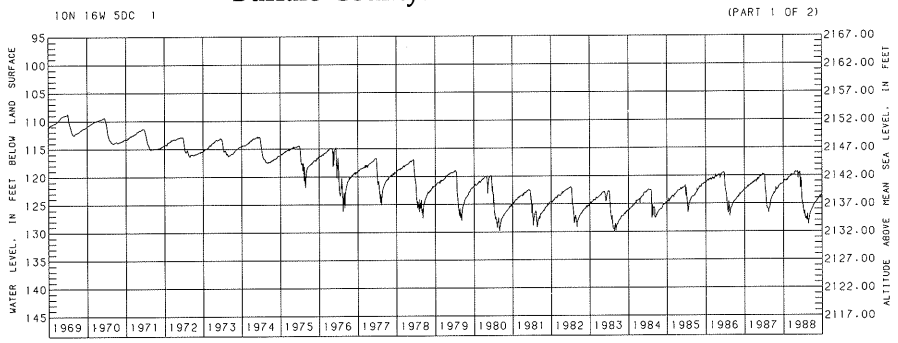


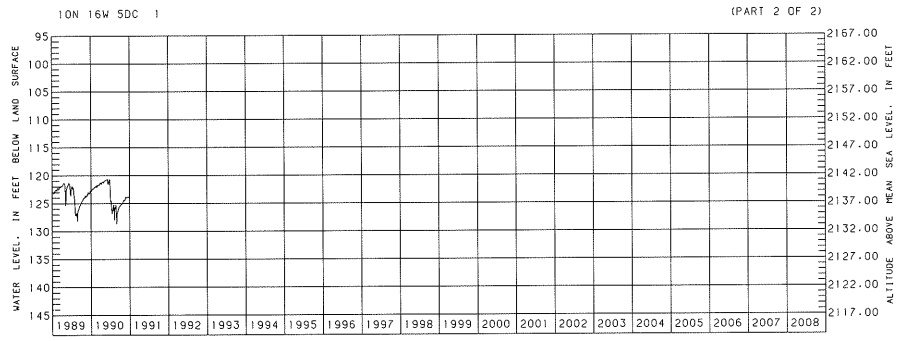




Buffalo County: Riverdale Recorder Well

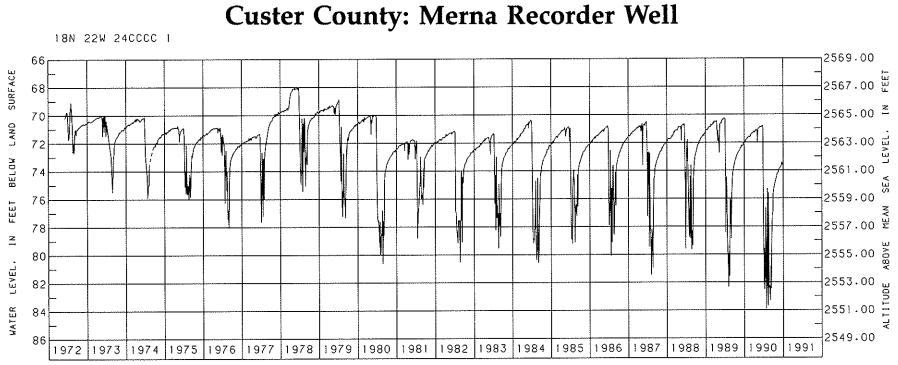
Estimated predevelopment water level: 107 feet
Net water-level change in 1990: -0.82 foot
Net water-level change since 1968: -12.54 feet





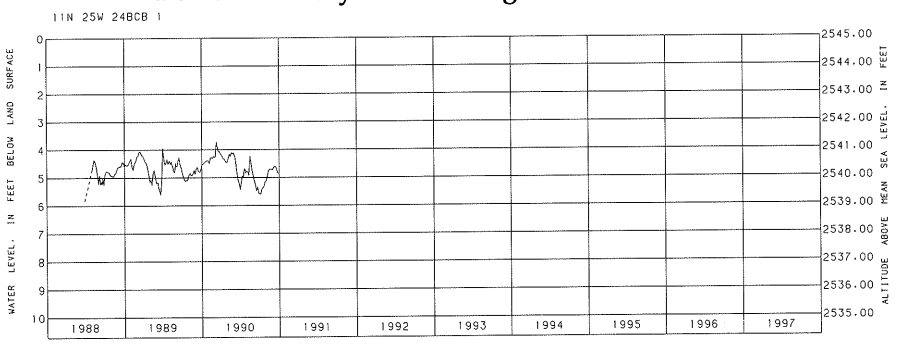
Custer County: Merna Recorder Well

Estimated predevelopment water level: 68 feet
Net water-level change in 1990: -1.46 feet
Net water-level change since 1972: -2.89 feet



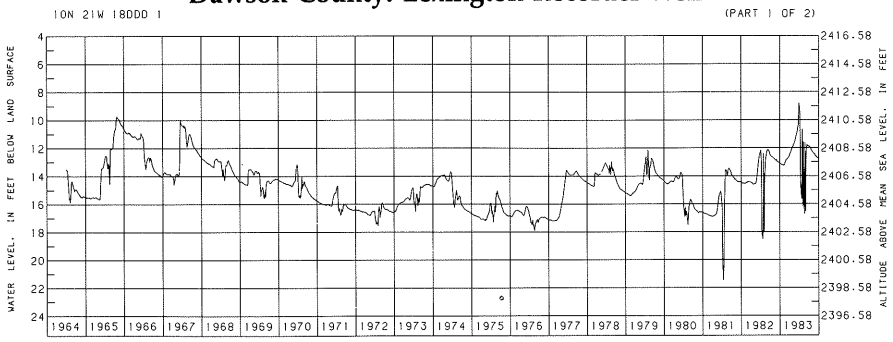
Dawson County: Gothenburg Recorder Well

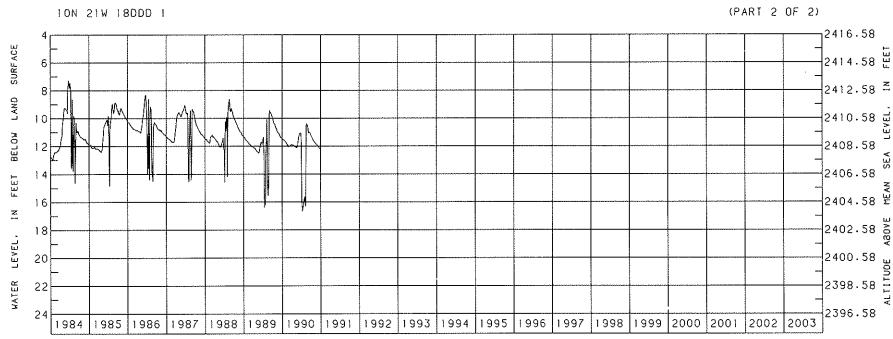
Estimated predevelopment water level: 4 feet
Net water-level change in 1990: -0.31 foot
Net water-level change since 1988: -0.26 foot



Dawson County: Lexington Recorder Well

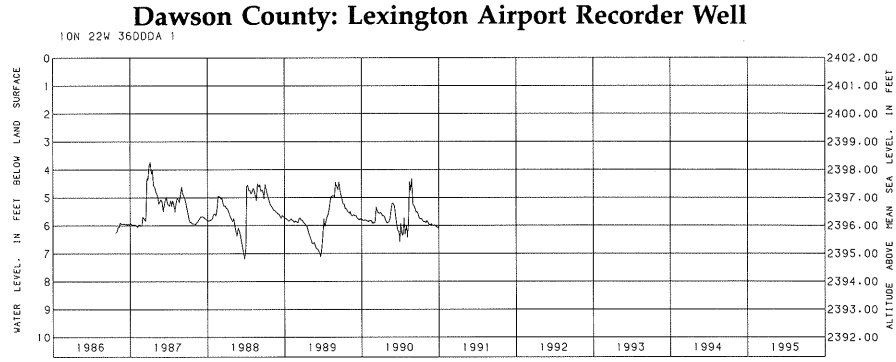
Estimated predevelopment water level: 11 feet
Net water-level change in 1990: -0.75 foot
Net water-level change since 1964: +3.27 feet





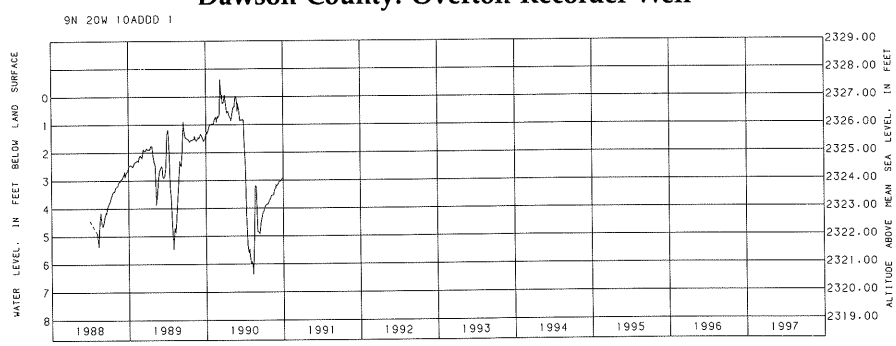
Dawson County: Lexington Airport Recorder Well

Estimated predevelopment water level: 4.5 feet
Net water-level change in 1990: -0.26 foot
Net water-level change since 1986: -0.12 foot



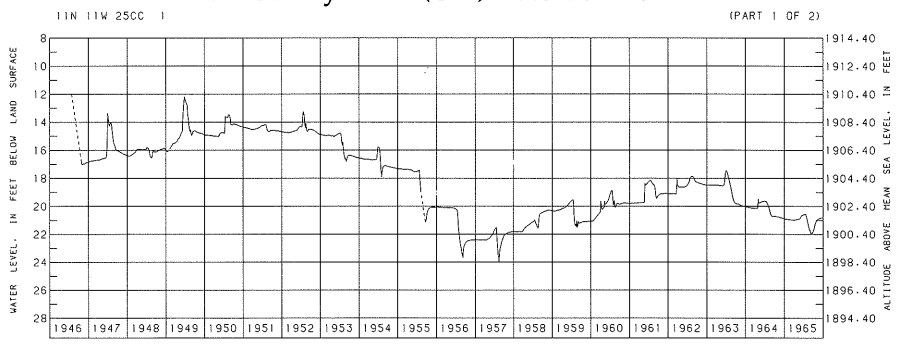
Dawson County: Overton Recorder Well

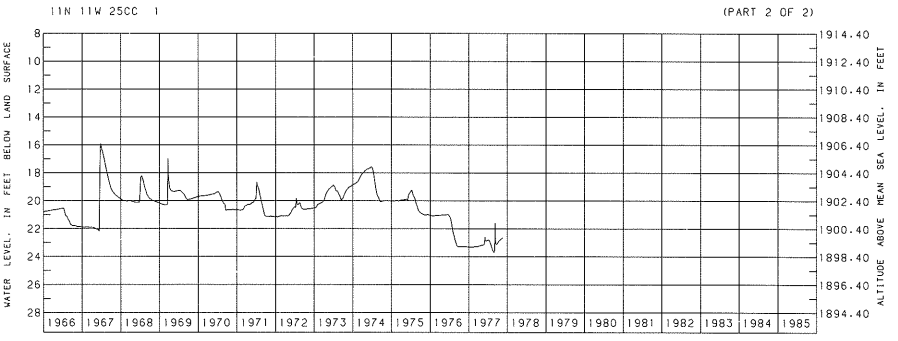
Estimated predevelopment water level: 1.5 feet
Net water-level change in 1990: -1.51 feet
Net water-level change since 1988: -0.34 foot



Hall County: Alda (Old) Recorder Well

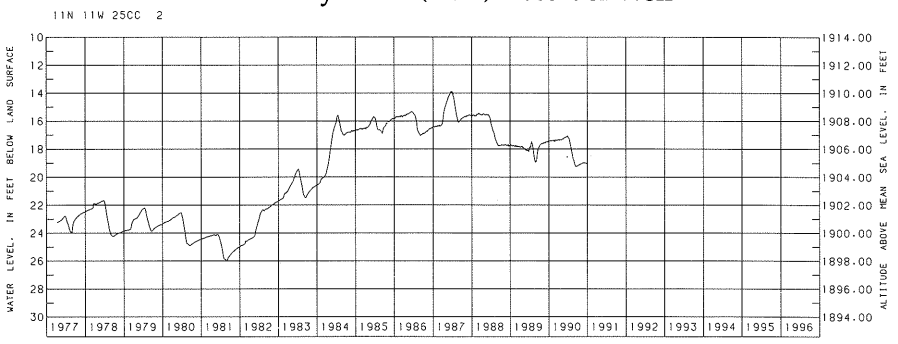
Estimated predevelopment water level: 15 feet
Well abandoned in 1977
Net water-level change from 1946 to 1976: -6.51 feet





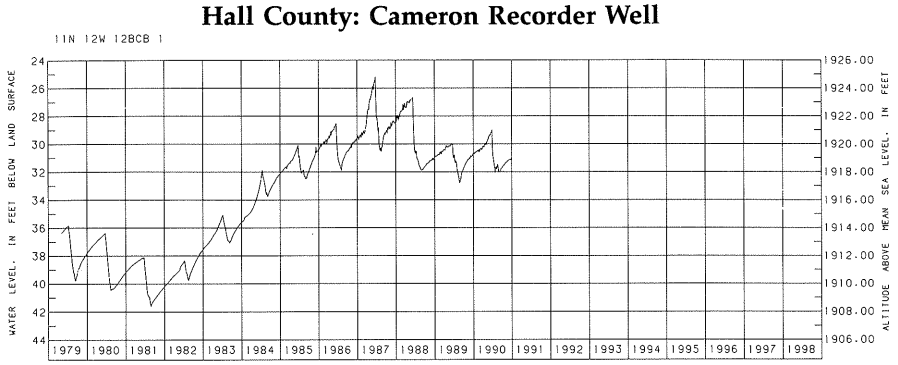
Hall County: Alda (New) Recorder Well

Estimated predevelopment water level: 15 feet
Net water-level change in 1990: -1.57 feet
Net water-level change since 1977: +3.45 feet



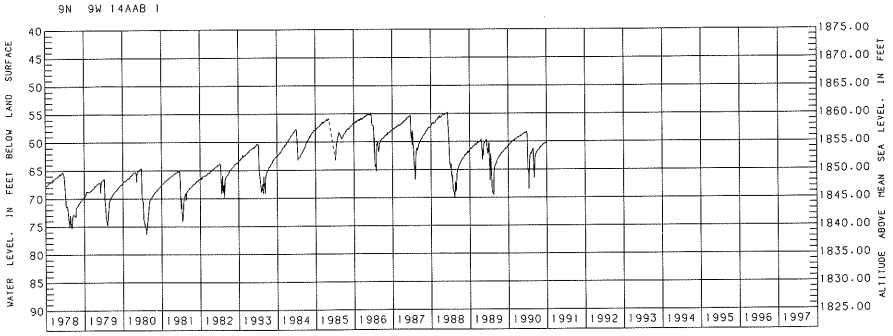
Hall County: Cameron Recorder Well

Estimated predevelopment water level: 27 feet
Net water-level change in 1990: -5.31 feet
Net water-level change since 1979: +1.76 feet



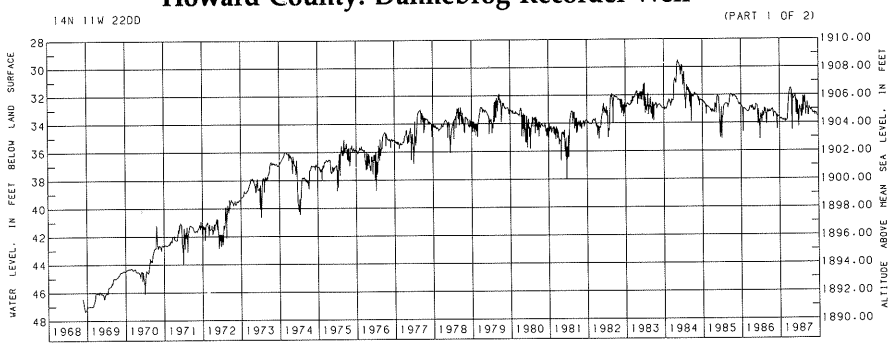
Hall County: Doniphan Recorder Well

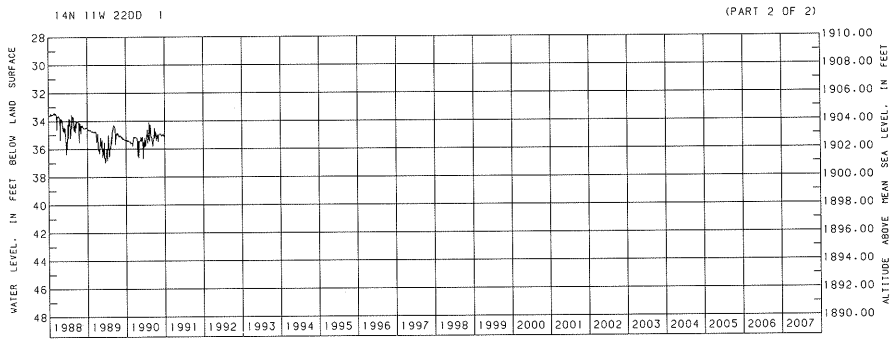
Estimated predevelopment water level: 63 feet
Net water-level change in 1990: +0.71 foot
Net water-level change since 1977: +7.68 feet



Howard County: Dannebrog Recorder Well

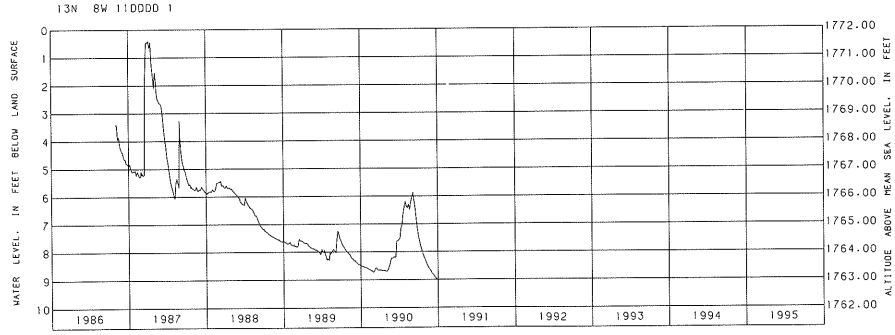
Estimated predevelopment water level: 62 feet
Net water-level change in 1990: +0.24 foot
Net water-level change since 1968: +11.95 feet





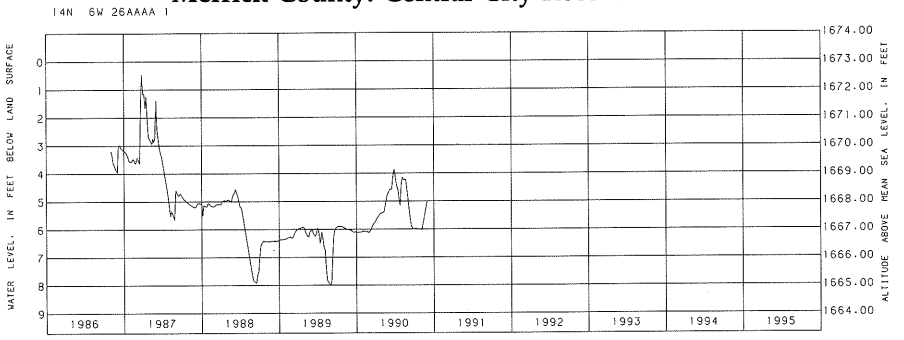
Merrick County: Archer Recorder Well

Estimated predevelopment water level: 3.5 feet
Net water-level change in 1990: -0.54 foot
Net water-level change since 1986: -4.12 feet



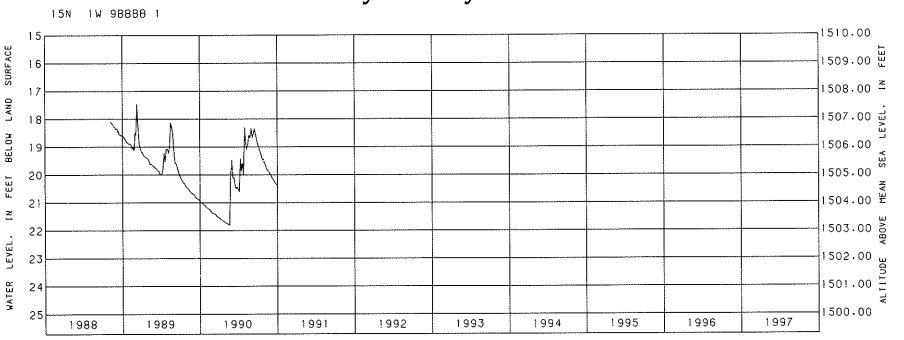
Merrick County: Central City Recorder Well

Estimated predevelopment water level: 2.5 feet
Net water-level change in 1990: -0.05 foot
Net water-level change since 1986: -2.97 feet



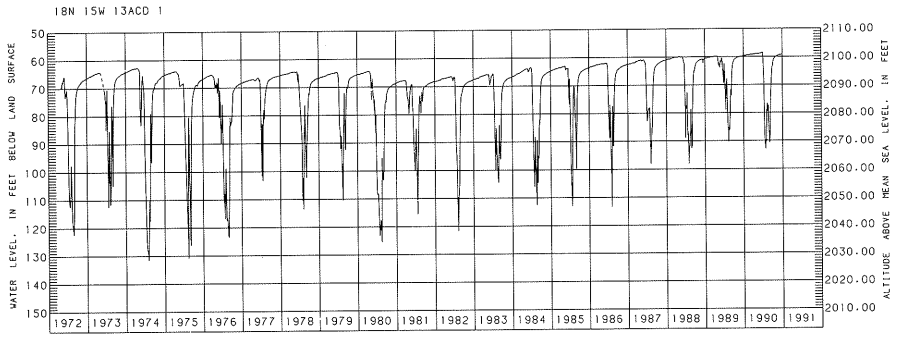
Polk County: Shelby Recorder Well

Estimated predevelopment water level: not determined
Net water-level change in 1990: +0.57 foot
Net water-level change since 1988: -1.76 feet



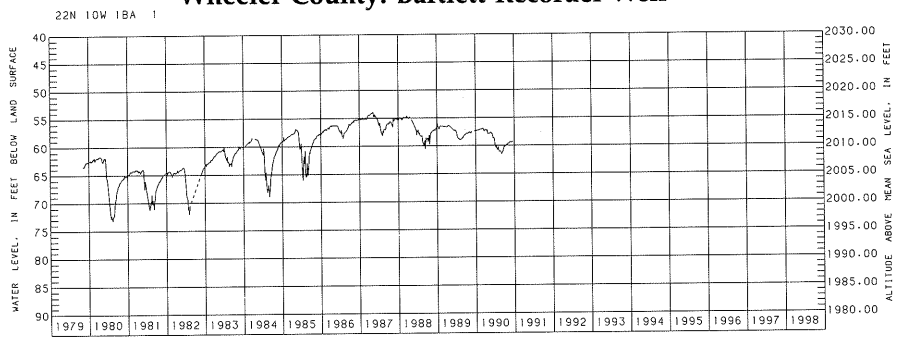
Valley County: Ord Recorder Well

Estimated predevelopment water level: 51 feet
Net water-level change in 1990: +0.48 foot
Net water-level change since 1972: +7.01 feet



Wheeler County: Bartlett Recorder Well

Estimated predevelopment water level: 56 feet
Net water-level change in 1990: -1.80 feet
Net water-level change since 1979: +3.18 feet



About 84 percent of groundwater levels measured in the East North-Central Division during fall 1990 were lower than those measured in fall 1989.

East North-Central Division

During the spring and fall of 1990, most groundwater levels in the East North-Central Division generally were lower than they were during the spring and fall of 1989. Water levels in 80 percent of the 130 wells measured in the spring of 1990 were lower than they were in the spring of 1989. Most spring 1990 water levels were between 1 and 3 feet lower than spring 1989 water levels, but declines of about 8 feet occurred in parts of Rock and Holt counties. During the fall of 1990, water levels in 84 percent of the 180 wells measured were lower than those measured in the fall of 1989. The greatest water-level decline occurred in Holt County, where the fall 1990 water level in one well was about 8 feet lower than in fall of 1989. The greatest water-level rise occurred in Antelope County, where one well showed a rise of just over 5 feet from fall 1989 to fall 1990.

Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	130	80	-1.19
Fall	180	84	-1.06

In the fall of 1990, water-level declines of 5 to 20 feet from estimated predevelopment levels occurred in a total area of approximately 62,500 acres in northern Holt County. The largest decline, about 20 feet, occurred in a well northeast of O'Neill. Water-level declines of 5 to 17 feet occurred in other areas in the northern part of the county. Estimated predevelopment water levels in the East North-Central Division are the approximate water levels prior to 1957.

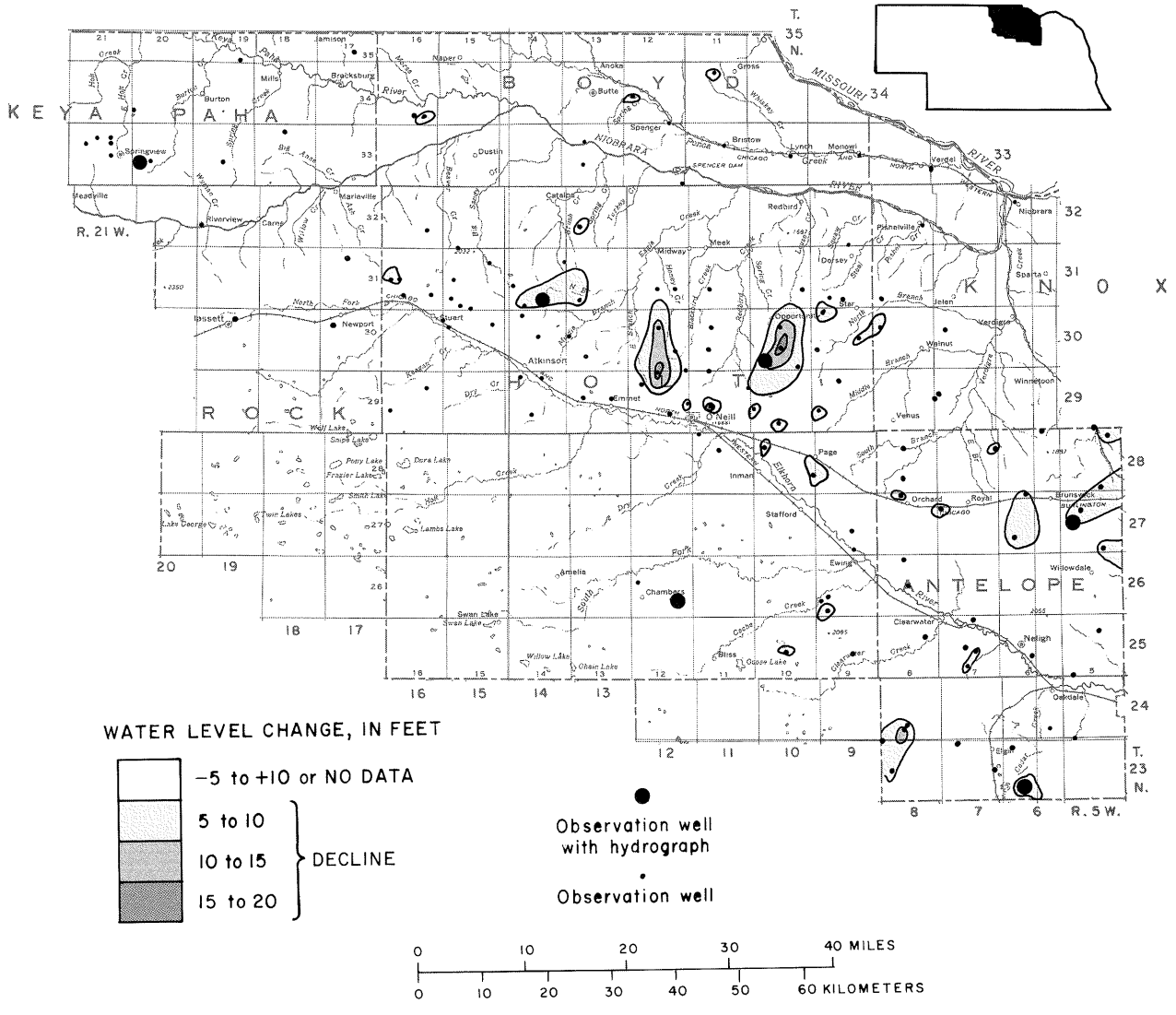
In the Holt County area the approximate areas of significant declines from estimated predevelopment to fall 1990 water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	51,000
10-15	9,800
15-20	1,700

Withdrawal of water for irrigation has caused progressive water-level declines in some parts of the division since 1964. However, recharge during periods of greater-than-normal precipitation occasionally has resulted in short-term water-level rises or lessening of the rate of water-level decline. Available data indicate that the water level in some wells declined at least 5 feet during the drought of the mid-1950s, that water levels in many wells rose more than 2 feet between 1970 and 1973, and that water levels in many wells rose as much as 10 feet between 1981 and 1987, when annual precipitation generally was greater than normal. In much of the area, however, groundwater withdrawals for irrigation are large enough to cause net water-level declines in most years when annual precipitation is about normal or less than normal.

At the end of 1990, there were about 4,600 registered irrigation wells in the division. Most of these wells are located in Antelope County and in the northern part of Holt County. During 1990, 69 new wells were drilled and registered.

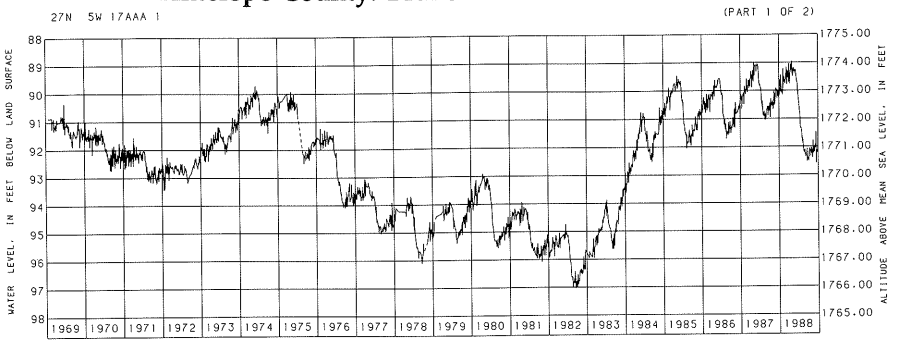
Sufficient data are available for a fairly good estimation of predevelopment water levels in the division, and the existing observation-well networks provide adequate data for evaluation of current water-level changes in most of the division. Prior to 1975, however, observation wells were too few to define the water-level changes adequately. Since 1975, water-level data collected by the Lower Niobrara and Upper Elkhorn natural resources districts have supplemented the data networks of the U.S. Bureau of Reclamation and the U.S. Geological Survey.

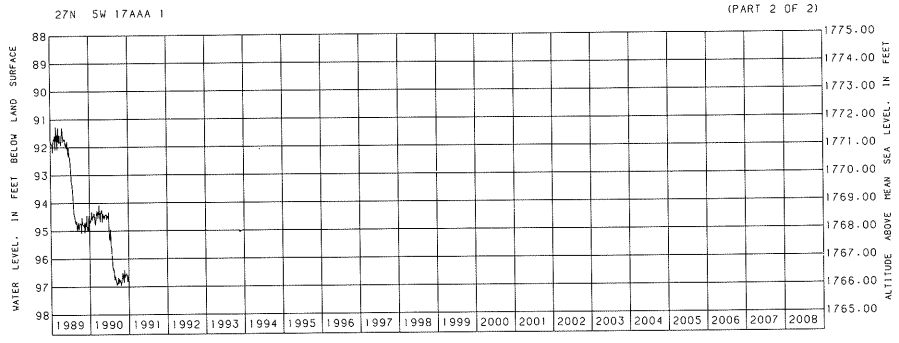


Areas of significant water-level change in the East North-Central Division from 1957 to fall 1990

Antelope County: Brunswick Recorder Well

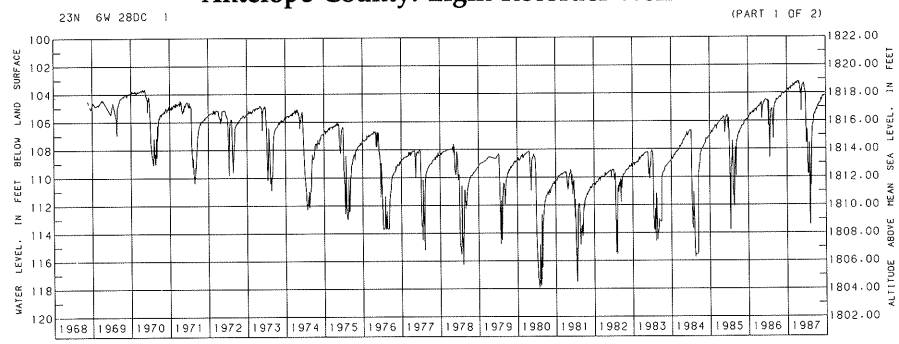
Estimated predevelopment water level: 90 feet
Net water-level change in 1990: -1.85 feet
Net water-level change since 1969: -5.24 feet

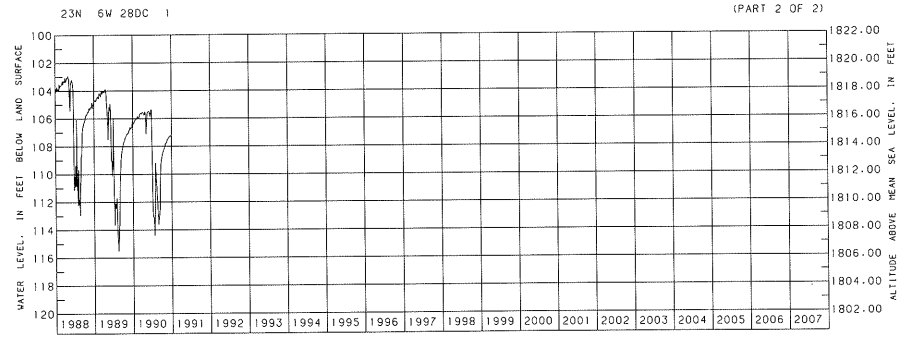




Antelope County: Elgin Recorder Well

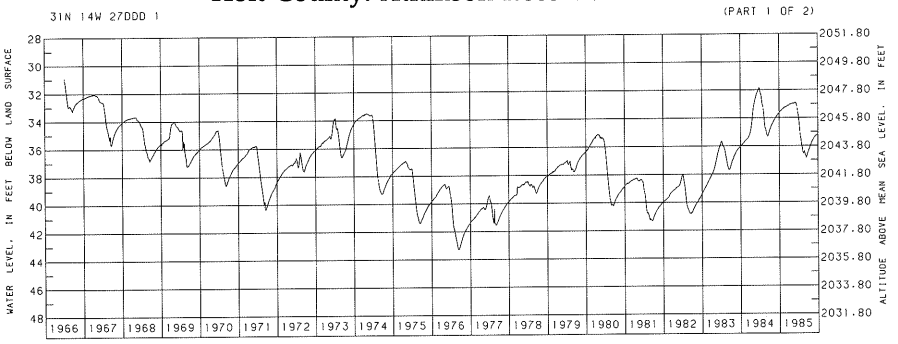
Estimated predevelopment water level: 102 feet
Net water-level change in 1990: -0.70 foot
Net water-level change since 1968: -2.28 feet

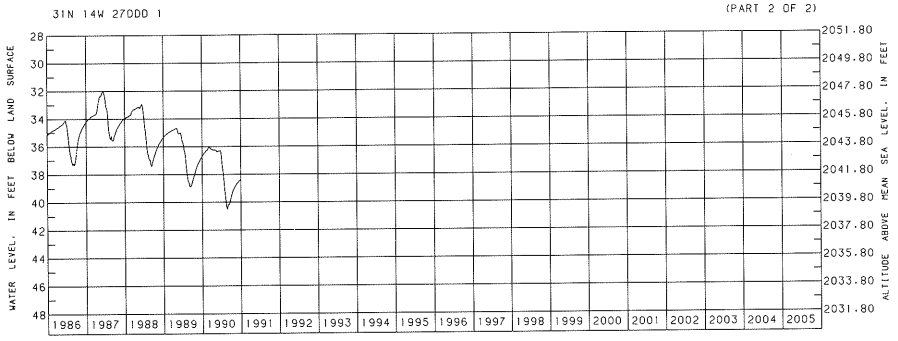




Holt County: Atkinson Recorder Well

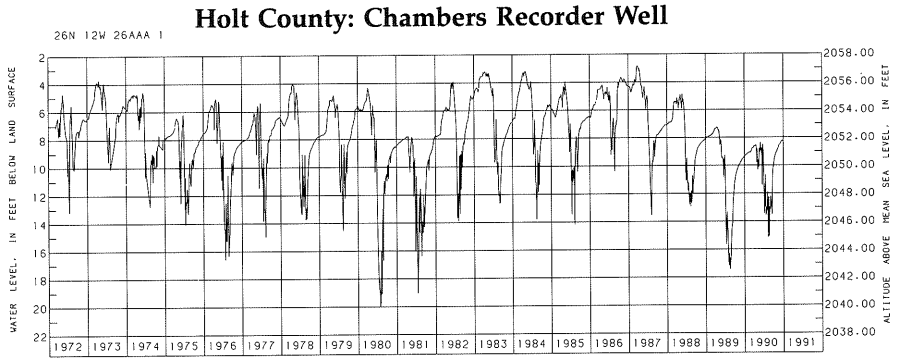
Estimated predevelopment water level: 32 feet
Net water-level change in 1990: -1.67 feet
Net water-level change since 1966: -6.07 feet





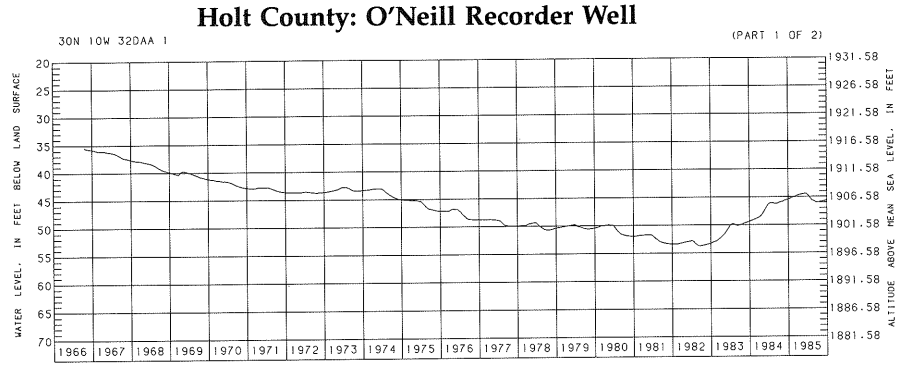
Holt County: Chambers Recorder Well

Estimated predevelopment water level: 6 feet
Net water-level change in 1990: +1.11 feet
Net water-level change since 1972: -1.81 feet

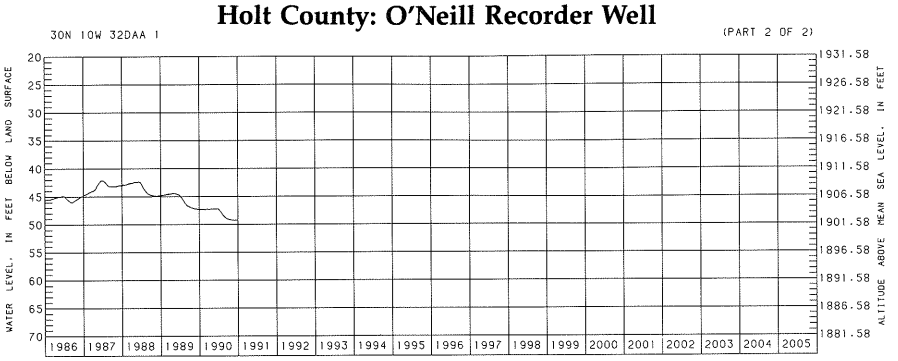


Holt County: O'Neill Recorder Well

Estimated predevelopment water level: 35 feet
Net water-level change in 1990: -1.93 feet
Net water-level change since 1966: -13.48 feet

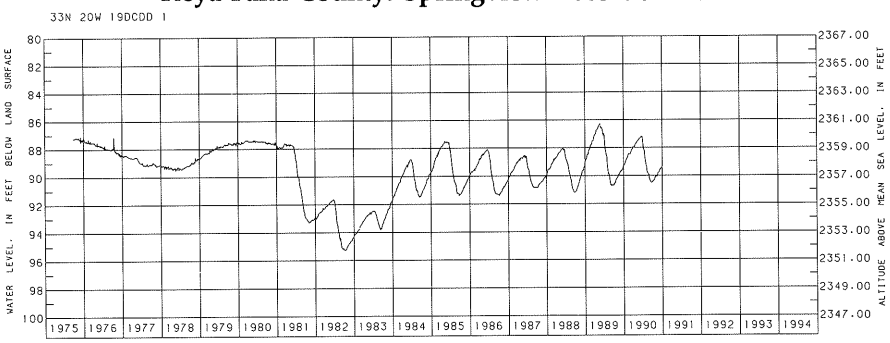


Holt County: O'Neill Recorder Well



Keya Paha County: Springview Recorder Well

Estimated predevelopment water level: 87 feet
Net water-level change in 1990: 0 feet
Net water-level change since 1975: -1.98 feet



In the Southwest Division, fall 1990 water levels generally were 1 to 5 feet lower than fall 1989 water levels.

Southwest Division

Spring 1990 water levels in the Southwest Division generally ranged between 1 foot higher and 1 foot lower than spring 1989 water levels. Most wells where spring 1990 water levels declined are located in Chase and Dundy counties. Perkins County and the southern parts of Keith and Lincoln counties also had large areas of water-level declines greater than 1 foot. Most water levels measured in the fall of 1990 generally were lower than those measured in the fall of 1989. Many fall 1990 water levels measured in Dundy, Chase, and Perkins counties were 1 to 5 feet lower than those measured in the fall of 1989. In the remaining counties, fall 1990 water levels generally were 1 foot higher to 2 feet lower than those measured in fall 1989.

Differences between water levels measured in 1990 and in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	402	83	-0.68
Fall	436	88	-1.44

Water-level rises of about 32 feet from predevelopment levels have occurred in an area of about 551,000 acres south of the South Platte and Platte rivers in Frontier, Keith, Lincoln, and Perkins counties. Seepage from Sutherland Reservoir, Lake Maloney, and their associated canals caused water levels to start rising west of North Platte in about 1935. East of North Platte, water levels began rising in about 1940 as a result of seepage from the Tri-County Supply Canal and Jeffrey Reservoir. Water levels have risen as much as 32 feet in a well north of Dickens in Lincoln County. In the immediate vicinity of Sutherland Reservoir, Lake Maloney, and Jeffrey Reservoir, water levels have risen about 50 feet. Since the mid-1970s, increased use of groundwater for irrigation has caused water-level declines in some wells within these areas of large water-level rises. For example, data for the Lake Maloney well in Lincoln County shows a decline of over 5 feet since 1978, but the water levels in the well are still about 20 feet higher than the estimated predevelopment level.

Approximate areas of significant rises from estimated predevelopment to fall 1990 water levels were:

Range of rise, in feet	Approximate area of rise, in acres
10-20	334,000
20-50	212,000
50 or more	4,800

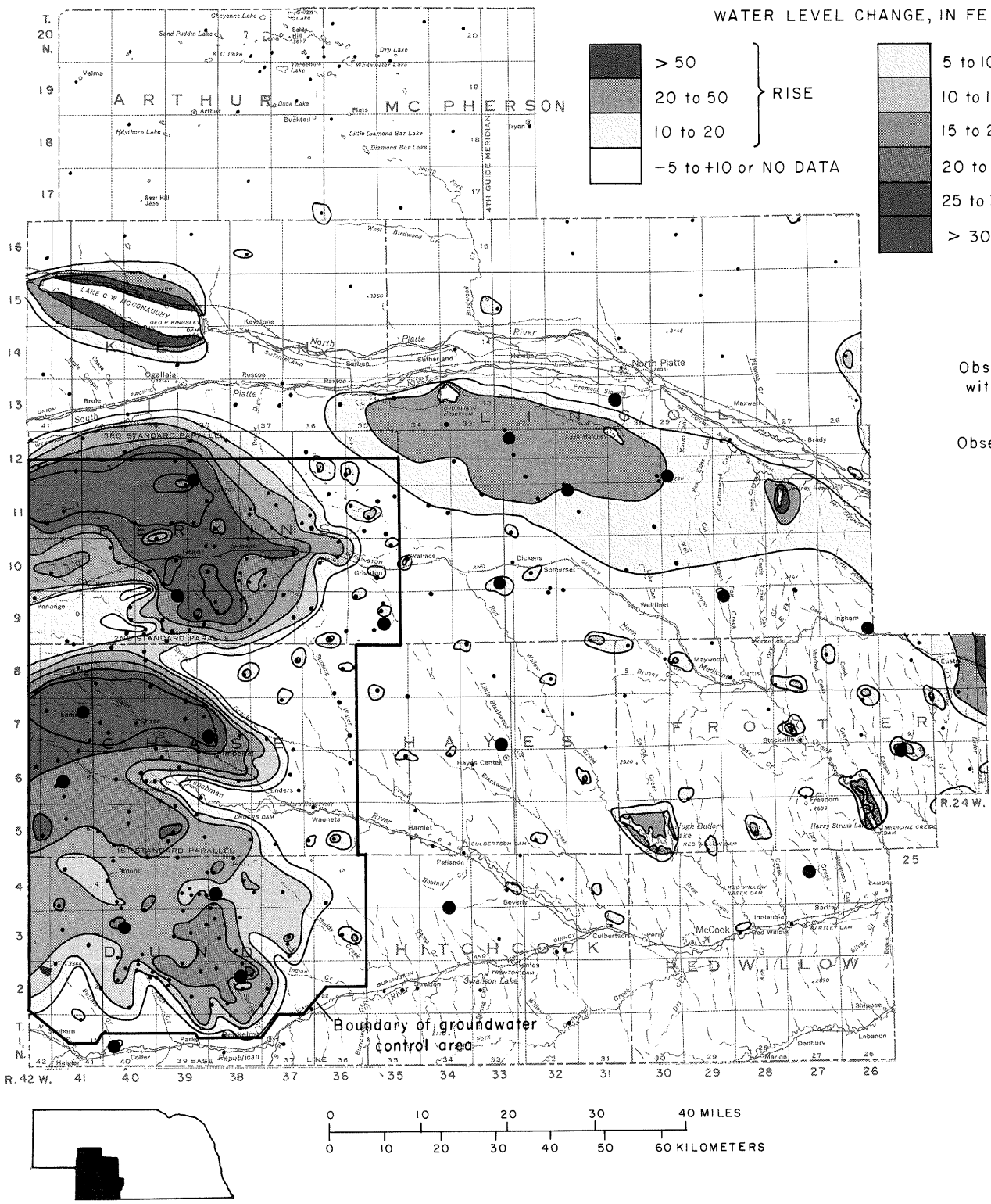
Storage of water in Lake McConaughy started in 1941, and seepage losses caused water-level rises of up to 60 feet in nearby observation wells. Water levels generally had stabilized by about 1950 and since then have fluctuated in response to changes in reservoir levels and precipitation. Data provided by the Central Nebraska Public Power and Irrigation District made it possible to delineate the water-level rise around Lake McConaughy. Surface-water developments in Frontier, Hayes, Hitchcock, and Red Willow counties have caused local water-level rises, but data are inadequate for accurately delineating those areas.

Declines of 5 to 49 feet from estimated predevelopment levels have occurred in approximately 1.35 million acres in Dundy, Chase, and Perkins counties. During the fall of 1990, declines from estimated predevelopment levels ranged from 5 to 30 feet in most of the area, but local declines of up to 49 feet occurred in parts of Chase and Perkins counties. In this area of water-level declines, estimated predevelopment water levels are based on data collected prior to 1935.

As of fall 1990, the approximate areas of water-level declines from estimated predevelopment water levels were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	276,000
10-15	208,000
15-20	319,000
20-25	238,000
25-30	151,000
30 or more	159,000

Available data indicate that as a result of intensive use of groundwater for irrigation, a trend of declining water levels started about 1966 in Dundy, Chase, Perkins and Keith counties. Interruption of these progressive water-level declines occurred during 1981 and 1982, when levels rose in most wells due to greater-than-normal precipitation. With the return of near-normal or less-than-normal precipitation since 1983, water-level declines have resumed. Continued less-than-normal precipitation in the Southwest Division during the summer of 1990, following 2 years of drought, resulted in at least 10 percent of the new irrigation wells in the state being drilled in this division during 1990. Thirty-five of the 76 new irrigation wells in the Southwest Division were drilled in Dundy, Chase, and Perkins counties.



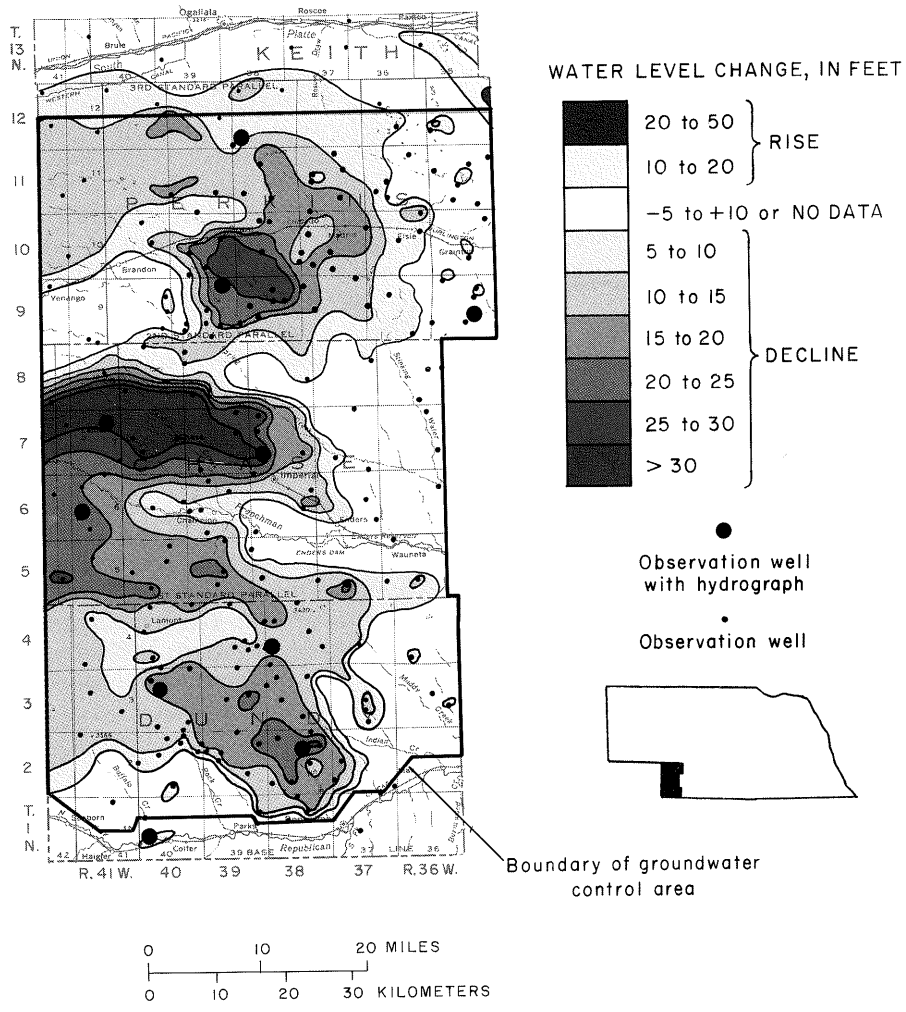
Areas of significant water-level change in the Southwest Division from 1935 to fall 1990

In most of the division, data are sufficient to make fairly good estimates of predevelopment water levels. Measurements made by the Middle Republican, Twin Platte, and Upper Republican natural resources districts and the U.S. Geological Survey provide adequate data for determining current water-level changes.

In the Upper Republican Ground Water Control Area, spring 1990 water levels were 5 to 42 feet lower than the estimated predevelopment levels in an area of about 1.17 million acres.

Approximate areas of water-level declines from estimated predevelopment water levels in the spring of 1990 were:

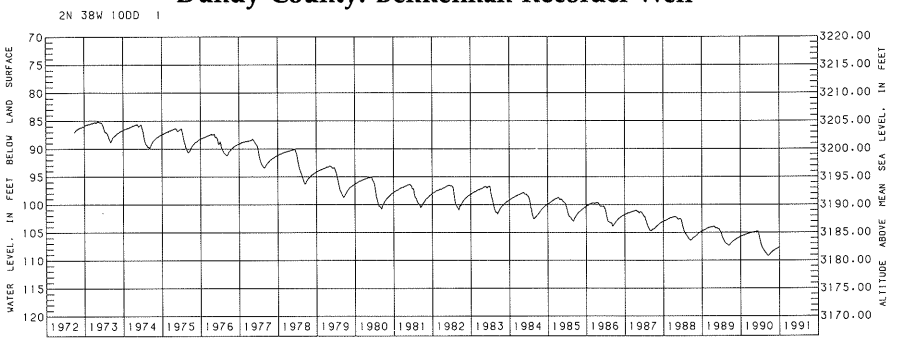
Range of decline, in feet	Approximate area of decline, in acres
5-10	345,000
10-15	408,000
15-20	216,000
20-25	101,000
25-30	52,000
30 or more	52,000



Areas of significant water-level change in Dundy, Chase, Perkins, and southern Keith counties from 1935 to spring 1990

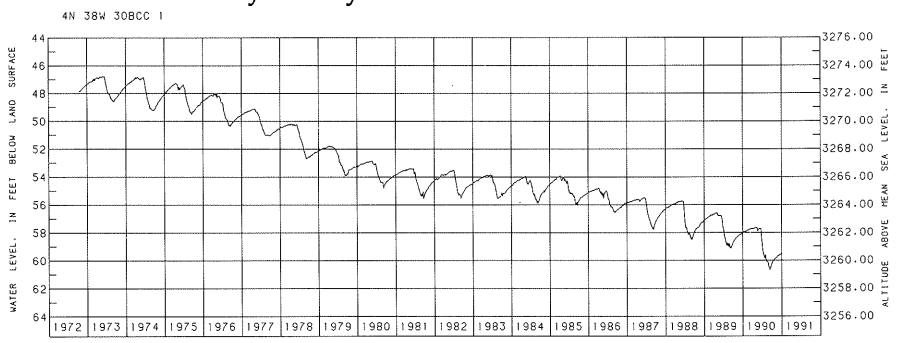
Dundy County: Benkelman Recorder Well

Estimated predevelopment water level: 84 feet
Net water-level change in 1990: -1.98 feet
Net water-level change since 1972: -21.70 feet



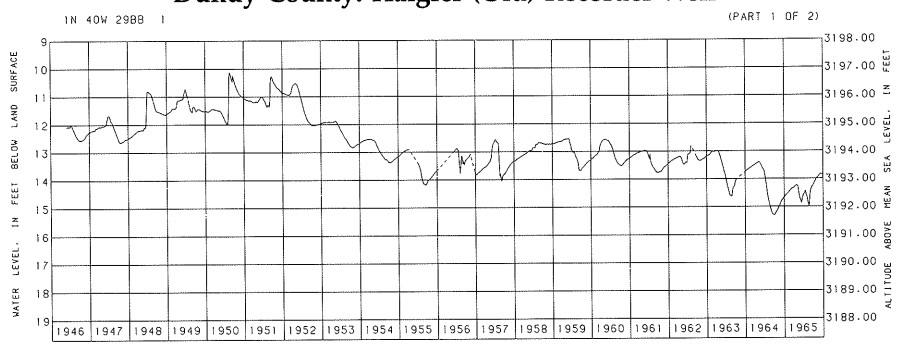
Dundy County: Enders Recorder Well

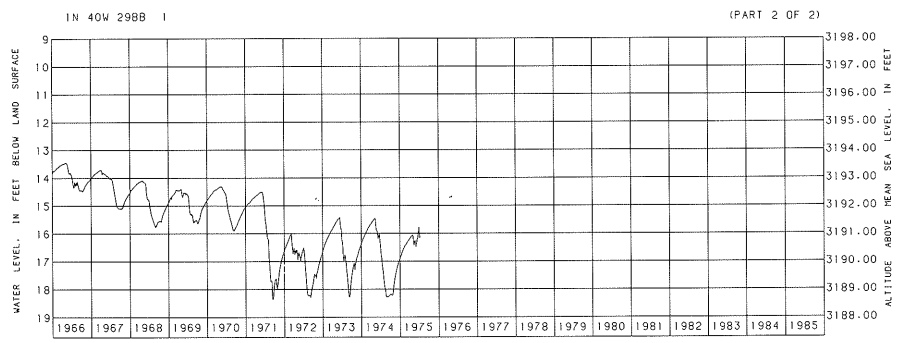
Estimated predevelopment water level: 46 feet
Net water-level change in 1990: -1.50 feet
Net water-level change since 1972: -12.18 feet



Dundy County: Haigler (Old) Recorder Well

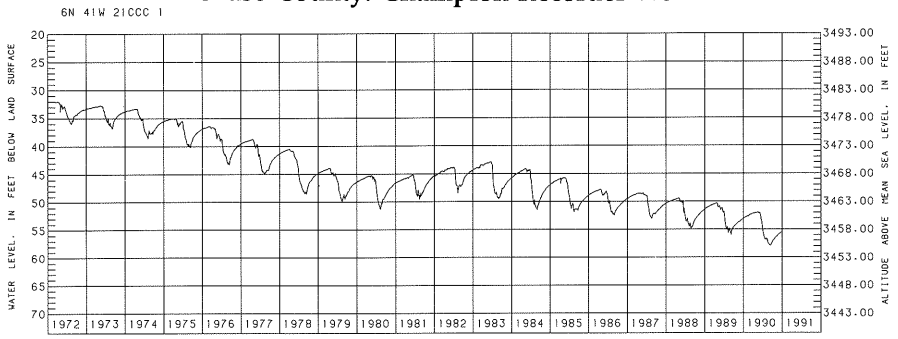
Estimated predevelopment water level: 12 feet
Well abandoned in 1975
Net water-level change from 1946 to 1975: -4.63 feet





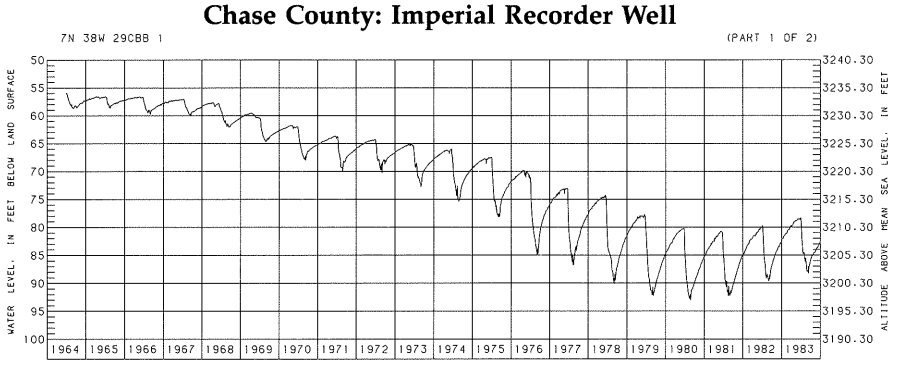
Chase County: Champion Recorder Well

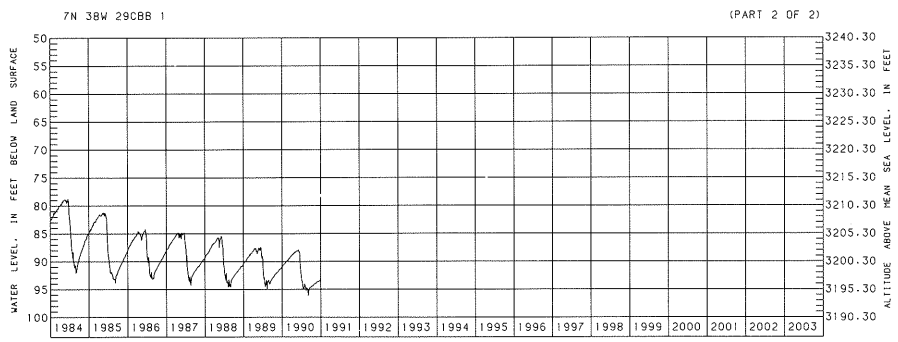
Estimated predevelopment water level: 30 feet
Net water-level change in 1990: -2.35 feet
Net water-level change since 1972: -22.09 feet



Chase County: Imperial Recorder Well

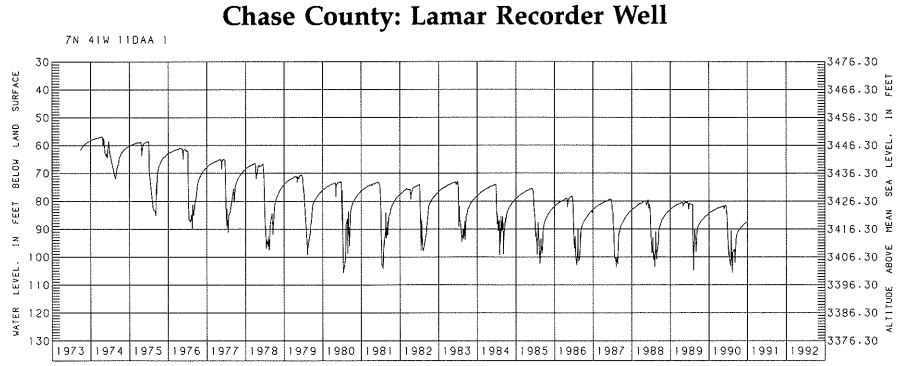
Estimated predevelopment water level: 56 feet
Net water-level change in 1990: -2.40 feet
Net water-level change since 1964: -35.94 feet





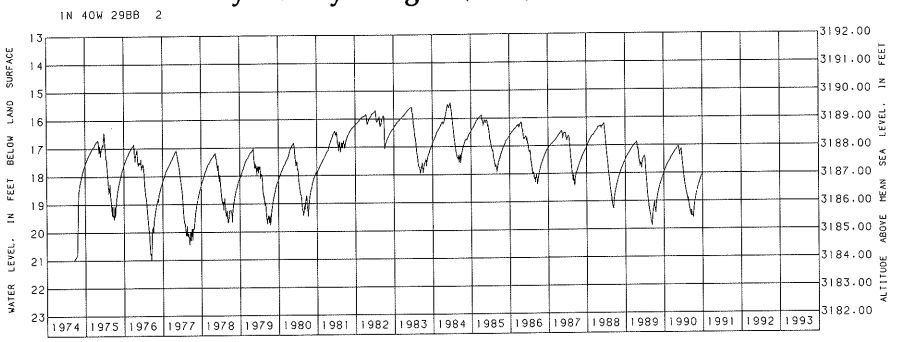
Chase County: Lamar Recorder Well

Estimated predevelopment water level: 50 feet
Net water-level change in 1990: -3.00 feet
Net water-level change since 1973: -29.03 feet



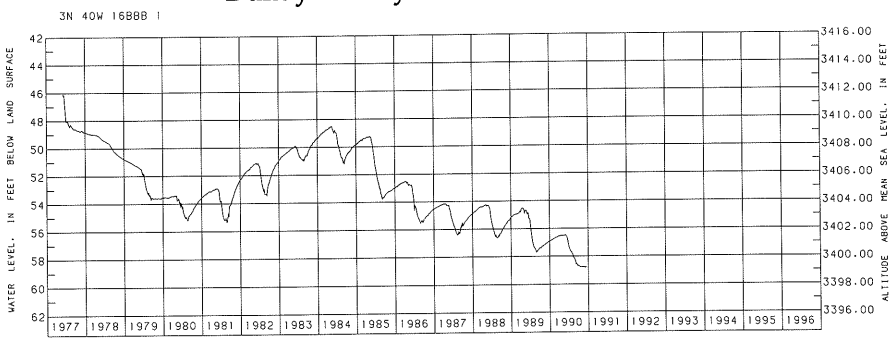
Dundy County: Haigler (New) Recorder Well

Estimated predevelopment water level: 10 feet
Net water-level change in 1990: -0.02 foot
Net water-level change since 1974: -0.44 foot



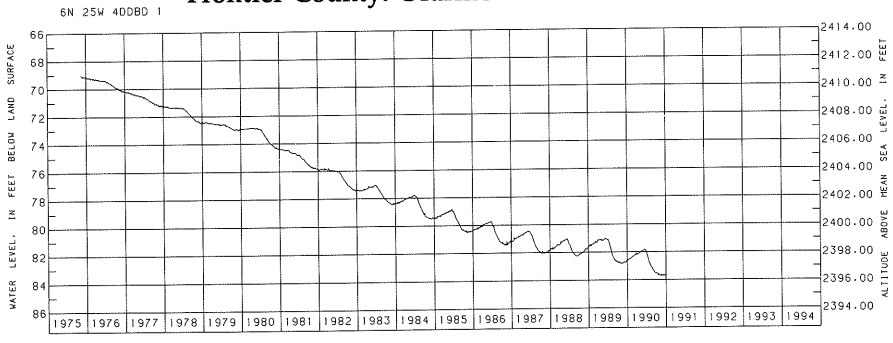
Dundy County: Lamont Recorder Well

Estimated predevelopment water level: 38 feet
Net water-level change in 1990: -1.90 feet
Net water-level change since 1977: -9.96 feet



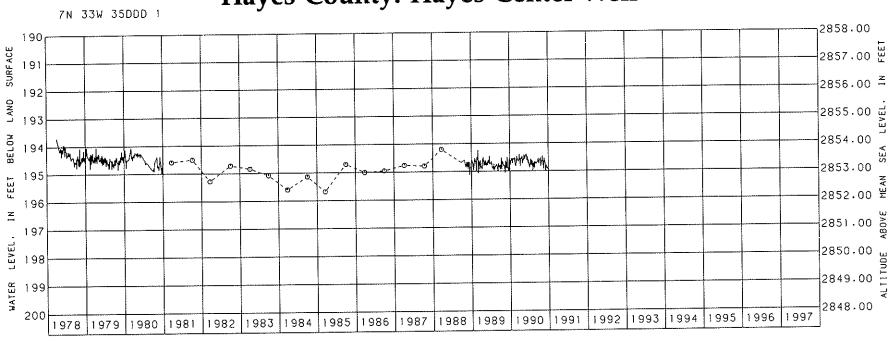
Frontier County: Orafino Recorder Well

Estimated predevelopment water level: 65 feet
Net water-level change in 1990: -0.97 foot
Net water-level change since 1975: -14.41 feet



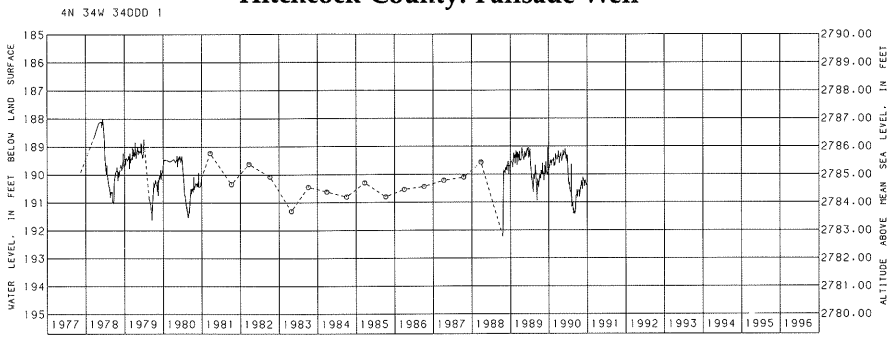
Hayes County: Hayes Center Well

Measured semiannually
Estimated predevelopment water level: 189 feet
Net water-level change, fall 1989 to fall 1990: -1.09 feet
Net water-level change since 1978: -1.15 feet



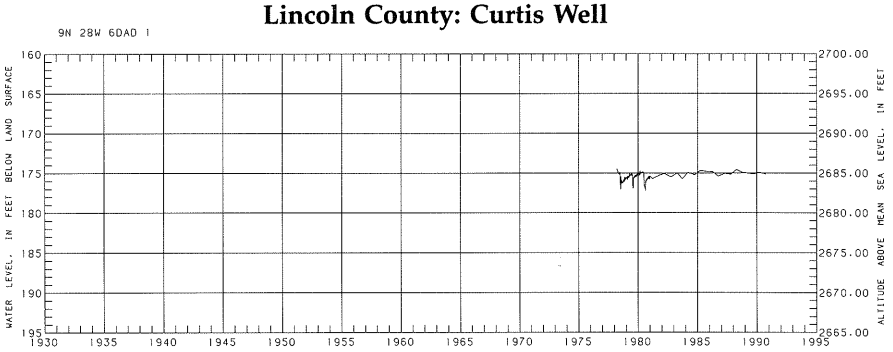
Hitchcock County: Palisade Well

Measured semiannually
Estimated predevelopment water level: 186 feet
Net water-level change, fall 1989 to fall 1990: -0.59 foot
Net water-level change since 1977: -0.23 foot



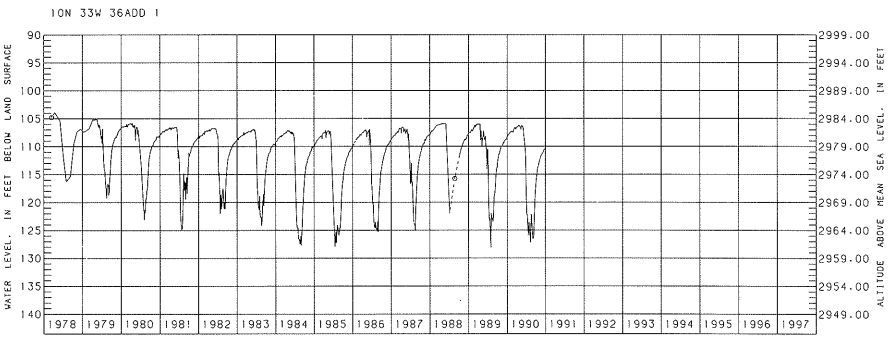
Lincoln County: Curtis Well

Measured semiannually
Estimated predevelopment water level: 169 feet
Net water-level change, fall 1989 to fall 1990: + 0.01 foot
Net water-level change since 1978: - 0.19 foot



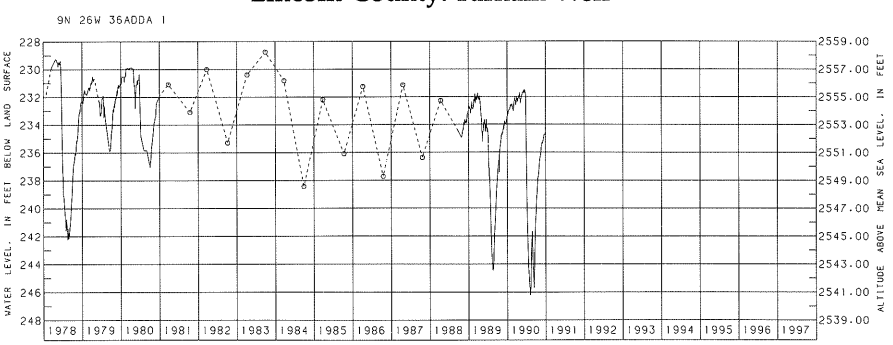
Lincoln County: Dickens Recorder Well

Estimated predevelopment water level: 105 feet
Net water-level change in 1990: -2.09 feet
Net water-level change since 1978: -3.14 feet



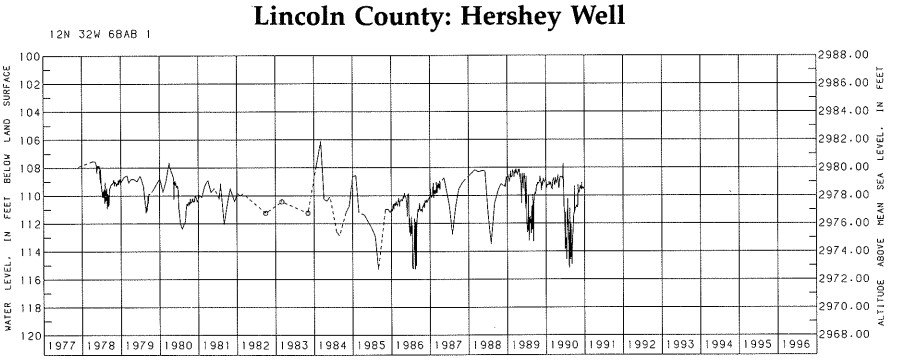
Lincoln County: Farnam Well

Measured semiannually
Estimated predevelopment water level: 243 feet
Net water-level change, fall 1989 to fall 1990: -1.16 feet
Net water-level change since 1978: +2.99 feet



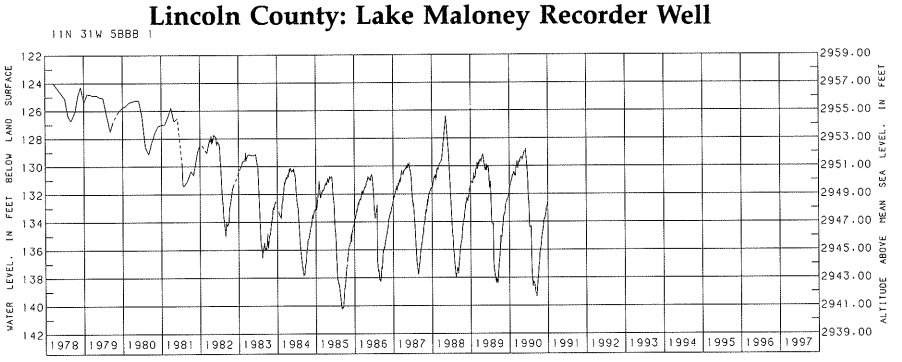
Lincoln County: Hershey Well

Measured monthly
Estimated predevelopment water level: 131 feet
Net water-level change in 1990: +0.37 foot
Net water-level change since 1977: -1.45 feet



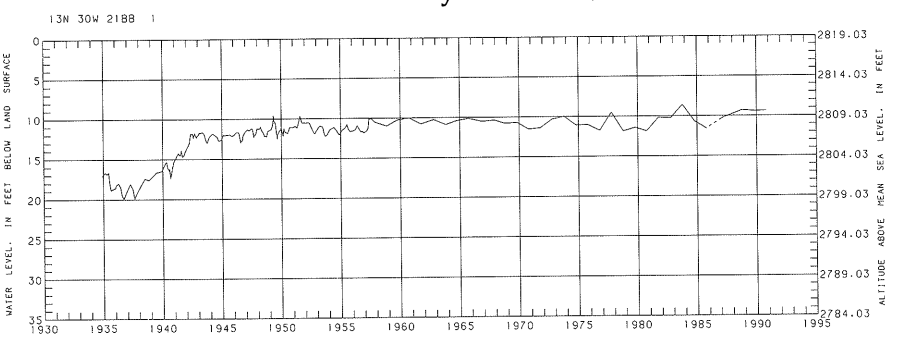
Lincoln County: Lake Maloney Recorder Well

Estimated predevelopment water level: 153 feet
Net water-level change in 1990: -0.92 foot
Net water-level change since 1978: -7.25 feet



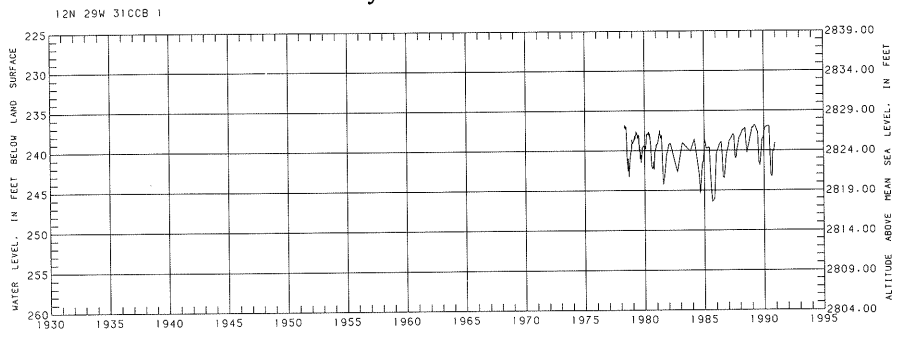
Lincoln County: Moran Well

Measured monthly
Estimated predevelopment water level: 254 feet
Net water-level change in 1990: -0.73 foot
Net water-level change since 1978: +0.59 foot



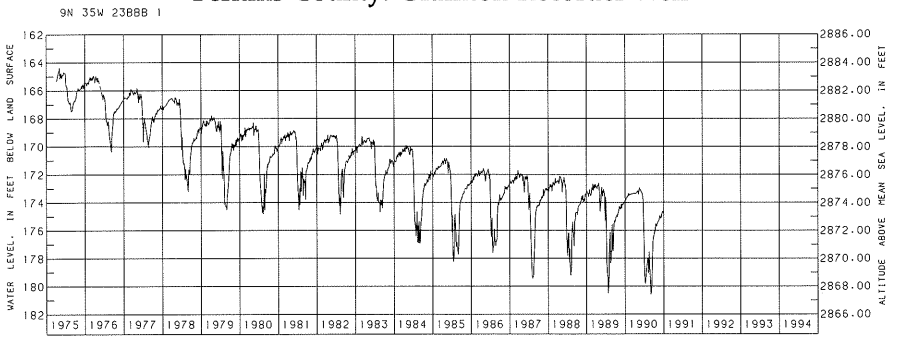
Lincoln County: North Platte Station Well

Measured annually
Estimated predevelopment water level: 17.8 feet
Net water-level change, fall 1989 to fall 1990: +0.03 foot
Net water-level change since 1934: +7.74 feet



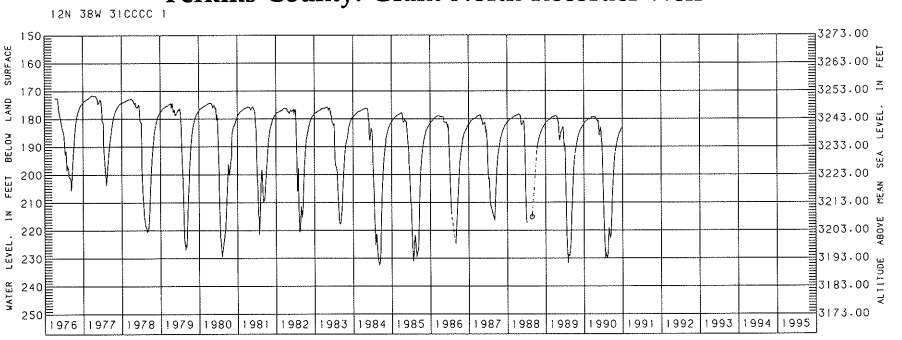
Perkins County: Grainton Recorder Well

Estimated predevelopment water level: 165 feet
Net water-level change in 1990: -0.79 foot
Net water-level change since 1975: -9.47 feet



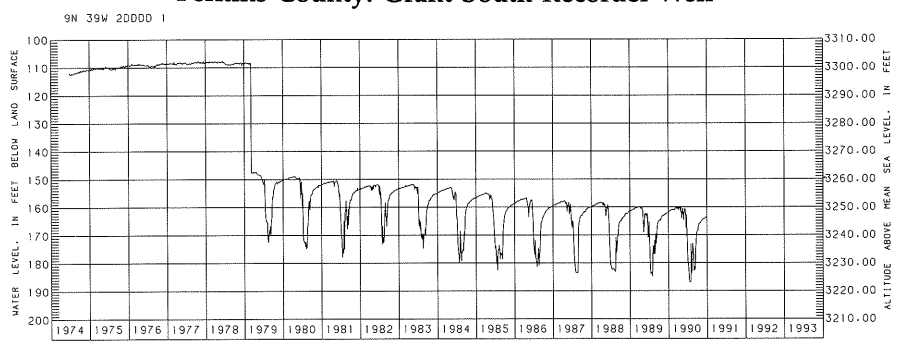
Perkins County: Grant North Recorder Well

Estimated predevelopment water level: 173 feet
Net water-level change in 1990: -1.14 feet
Net water-level change since 1976: -8.89 feet



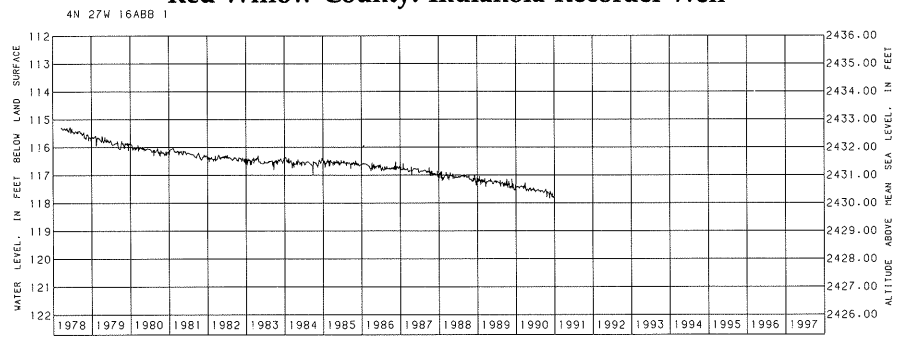
Perkins County: Grant South Recorder Well

Estimated predevelopment water level: 135 feet
Net water-level change in 1990: -1.84 feet
Net water-level change since 1979: -13.19 feet
See 1980 groundwater level report for explanation of well redevelopment.



Red Willow County: Indianola Recorder Well

Estimated predevelopment water level: 115 feet
Net water-level change in 1990: -0.26 foot
Net water-level change since 1978: -2.06 feet



West North-Central Division

Groundwater levels in the West North-Central Division generally were slightly lower during 1990 than they were during 1989. Throughout most of the division, water levels measured in 1990 generally ranged from 1 foot higher to 1 foot lower than water levels measured in 1989. In northern Brown County, available data indicate that significant areas of water-level declines occurred from spring 1989 to spring 1990. The largest decline was 2.7 feet in a Brown County well. Groundwater levels measured in the fall of 1990 indicate that most were slightly lower than fall 1989 water levels.

Groundwater levels in the West North-Central Division generally were slightly lower in 1990 than they were in 1989.

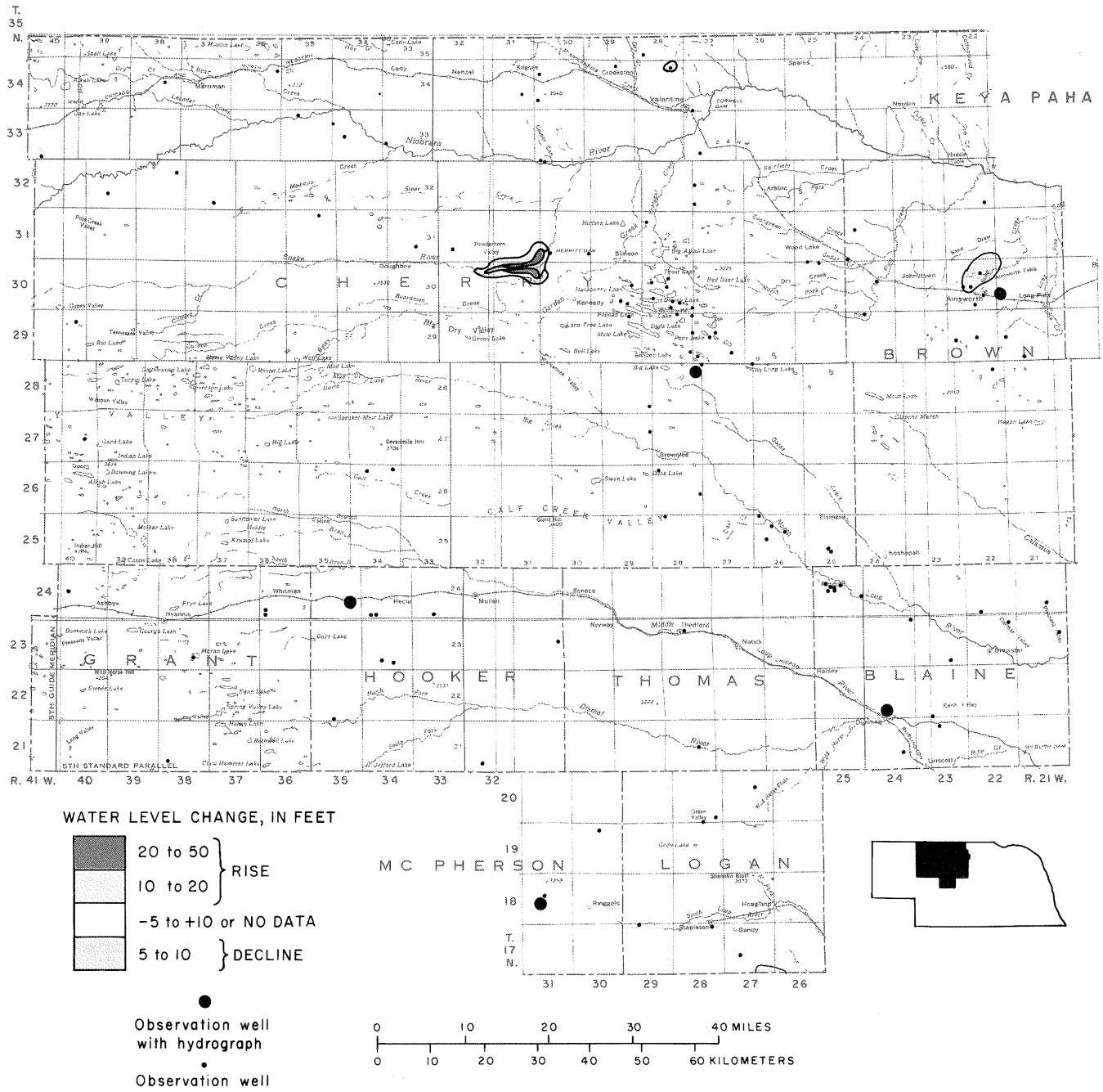
Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	18	39	-0.51
Fall	120	72	- .05

Available water-level data are insufficient to determine accurately areas of long-term rise or decline in the division, except for an area north of Ainsworth in Brown County. In this area, surface water diverted from the Snake River at Merritt Reservoir is used for irrigation. Deep percolation of seepage losses from the irrigation distribution system and of water applied to crops has caused water-level rises of almost 15 feet since 1965. Water levels also have risen near Merritt Reservoir, but the delineated area of rise is only an approximation because data are limited.

Long-term water-level records indicate that withdrawals of groundwater for irrigation have not caused any long-term declines in water levels in this division, even though the number of registered irrigation wells increased from 104 in 1955 to 1,394 in 1990. Only five new wells were drilled in the division during 1990, which is one fewer than was drilled in 1989. The average density of irrigation wells in the division is about one well per 8.5 square miles.

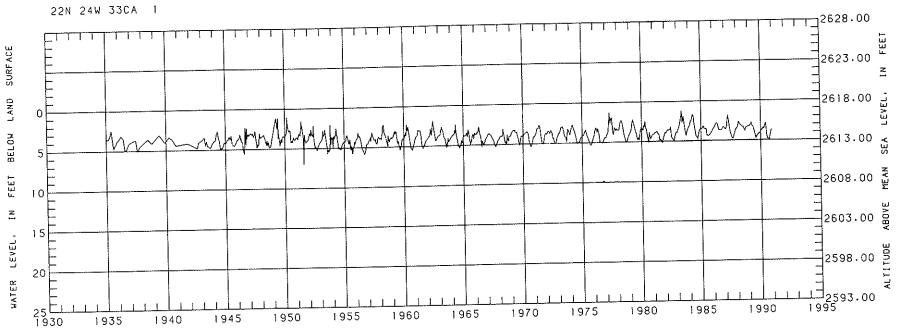
Water levels in the division are measured by the Middle Niobrara and Upper Loup natural resources districts, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey.



Areas of significant water-level change in the West North-Central Division from 1951 to fall 1990

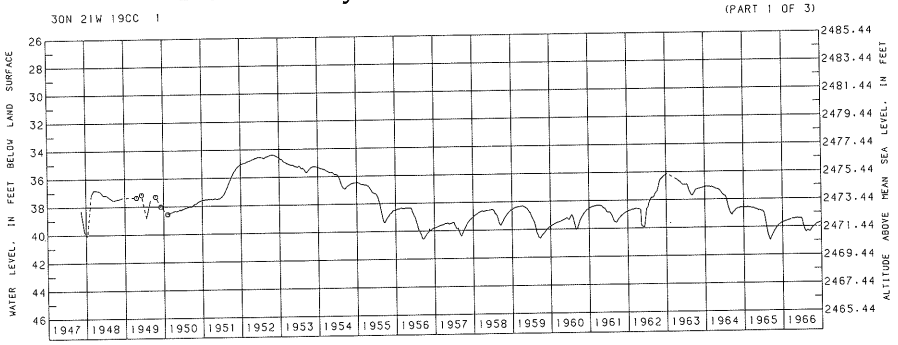
Blaine County: Dunning Well

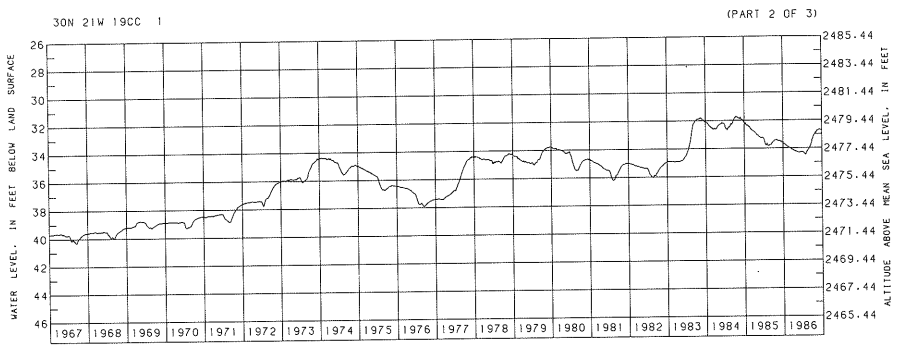
Measured monthly
Estimated predevelopment water level: 4 feet
Net water-level change in 1990: +0.35 foot
Net water-level change since 1934: +0.05 foot

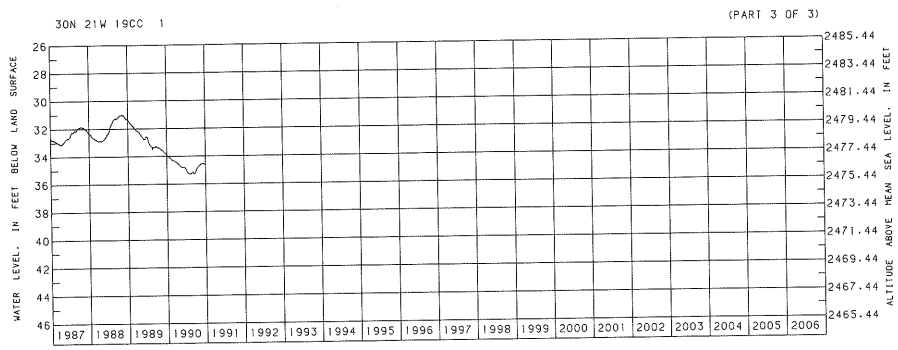


Brown County: Ainsworth Recorder Well

Estimated predevelopment water level: 37 feet
Net water-level change in 1990: -0.72 foot
Net water-level change since 1947: +5.35 feet

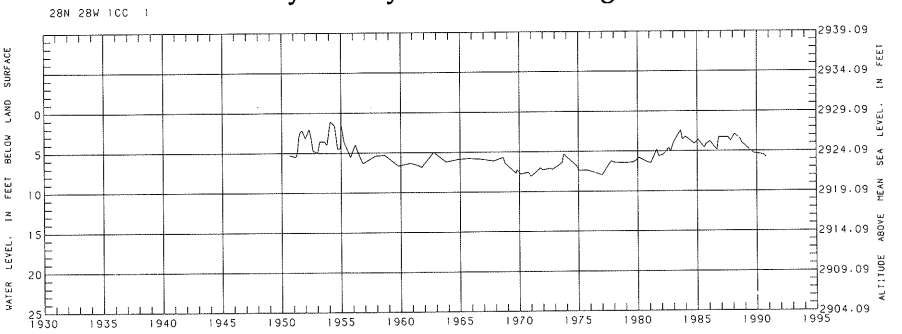






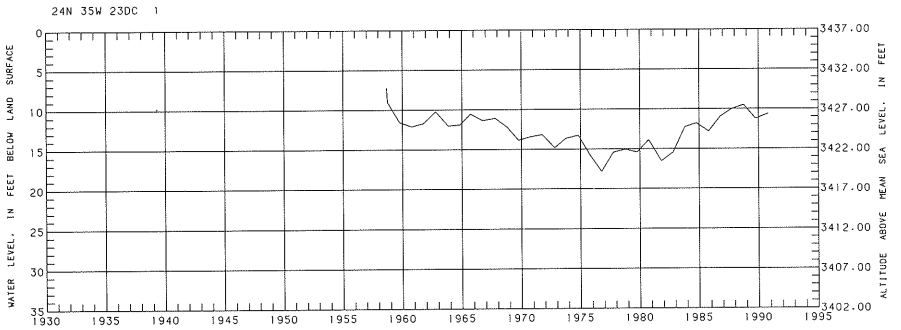
Cherry County: Valentine Refuge Well

Measured triannually
Estimated predevelopment water level: 4 feet
Net water-level change, fall 1989 to fall 1990: -1.70 feet
Net water-level change since 1950: -1.72 feet



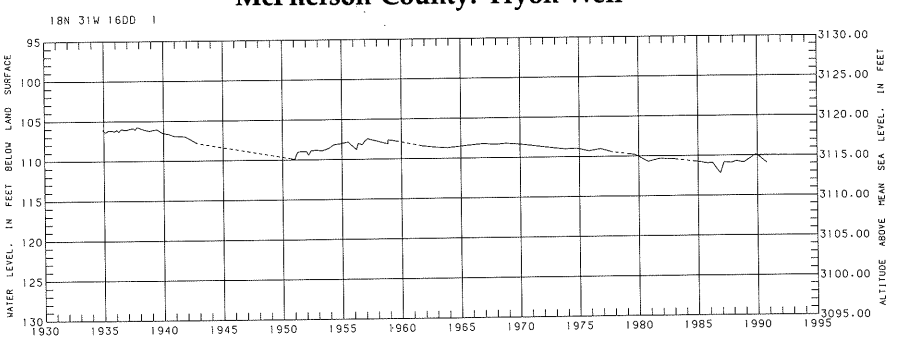
Hooker County: Hecla Well

Estimated predevelopment water level: 4 feet
Net water-level change in 1990: +0.63 foot
Net water-level change since 1958: -1.60 feet



McPherson County: Tryon Well

Measured semiannually
Estimated predevelopment water level: 108.8 feet
Net water-level change, fall 1989 to fall 1990: -0.86 foot
Net water-level change since 1934: -5.16 feet



In the Panhandle Division, 55 percent of the water levels measured in observation wells during the fall of 1990 were lower than those measured in the fall of 1989

Panhandle Division

Groundwater levels measured in most of the Panhandle Division in the spring of 1990 generally ranged between 1 and 2 feet lower than those measured in the spring of 1989. In Box Butte County, however, many spring 1990 water levels were 2 to 5 feet lower than those measured in the spring of 1989. During the fall of 1990, 55 percent of the water levels measured in observation wells were lower than those measured in the fall of 1989. Many areas in the North Platte River valley showed water-level declines of 1 to 2 feet from the fall of 1989 to the fall of 1990. Areas in the uplands showed water-level rises of 1 to 2 feet from fall 1989 to fall 1990. Box Butte County had water-level rises in most wells and two wells had fall 1990 readings of more than 10 feet higher than fall 1989.

Differences between water levels measured in 1990 and those measured in 1989 were:

Season	Number of wells measured	Wells with lower water levels in 1990, in percent	Average water-level difference, in feet
Spring	310	81	-1.74
Fall	290	55	.02

Intensive groundwater development for irrigation in Box Butte County has caused water-level declines of 5 to 90 feet from estimated predevelopment levels in an area of about 434,000 acres since 1950. A long-term decline of almost 60 feet from estimated predevelopment has occurred in the Alliance observation well located about 3 miles north of Alliance. Estimated predevelopment water levels in Box Butte County are the approximate water levels that occurred prior to 1946.

As of fall 1990, the approximate areas of significant water- level declines from estimated predevelopment water levels in Box Butte County were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	68,000
10-15	49,000
15-20	49,000
20-25	64,000
25-30	84,000
30 or more	120,000

Sufficient historical water-level data are available for making good estimates of predevelopment water levels in most of Box Butte County, and existing water-level measurement programs provide sufficient data for fairly good determination of current water-level changes throughout most of the county. Water-level data are collected by the Conservation and Survey Division in cooperation with the Upper Niobrara-White Natural Resources District and the U.S. Geological Survey.

Another area in the Panhandle Division where significant declines from predevelopment water levels have occurred is along the Lodgepole Creek valley and in the Sidney Draw area southwest of Sidney in Cheyenne County. Groundwater withdrawals for irrigation have resulted in declining water levels during most years since 1969. Declines of 5 to 27 feet have occurred in an area of approximately 39,000 acres. Declines of 14 to 24 feet from the estimated predevelopment level were observed in several observation wells in the Lodgepole Creek valley west of Sidney. During periods of greater-than-normal precipitation, such as 1982-83 and 1986-87, water levels rose in many wells. Estimated predevelopment water levels in the Lodgepole Creek valley and Sidney Draw are the approximate water levels prior to 1950. Water-level data collected by the Conservation and Survey Division in cooperation with South Platte Natural Resources District and the U.S. Geological Survey are used for determining these water-level changes.

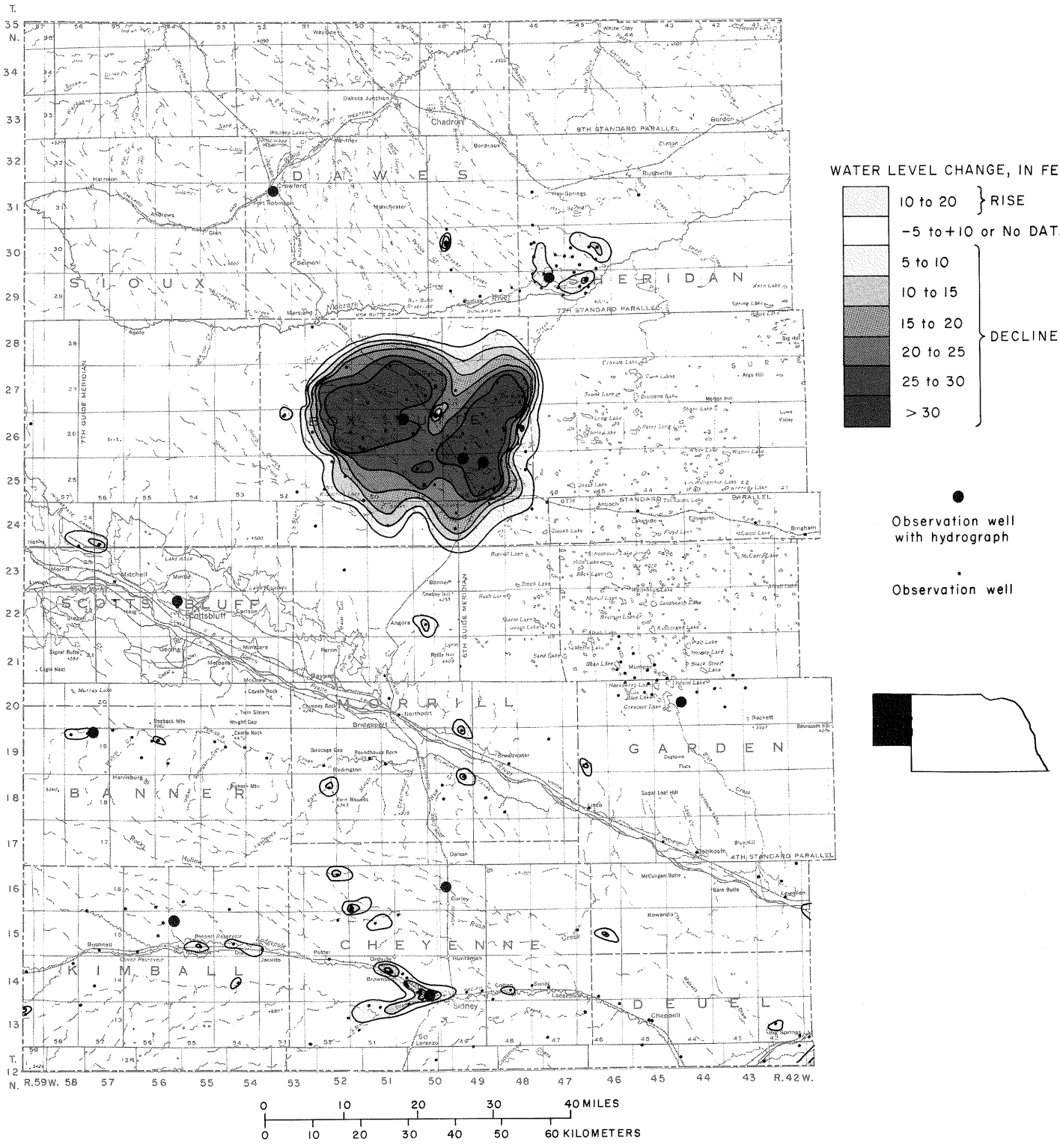
During the fall of 1990, the approximate areas of significant water-level declines from estimated predevelopment water levels in the Lodgepole Creek valley and Sidney Draw were:

Range of decline, in feet	Approximate area of decline, in acres
5-10	30,000
10-15	8,000
15-20	1,400

Water-level declines of at least 5 feet from estimated predevelopment levels also have occurred in upland areas in Cheyenne, Deuel, Kimball, Scotts Bluff, Sheridan, and Sioux counties and along Pumpkin Creek and its tributaries in Banner and Morrill counties. Available data are not sufficient for accurate delineation of most of these areas of decline.

One well that taps the Chadron Formation west of Chimney Rock near the Banner, Morrill, and Scotts Bluff county lines showed significant water-level fluctuations from 1989 to 1990. In the spring of 1990, this well showed a decline of 25 feet from spring of 1989. A water-level measurement at the same well in the fall of 1990 indicated a water-level rise of more than 16 feet from the fall of 1989. Water-level changes in wells developed in the Chadron Formation are more localized and, therefore, are not viewed as representative of the regional Pleistocene sands and gravels aquifer overlying the bedrock units. Therefore, they will not be shown on any of the maps indicating water-level changes from 1989 to 1990 or from predevelopment to fall 1990.

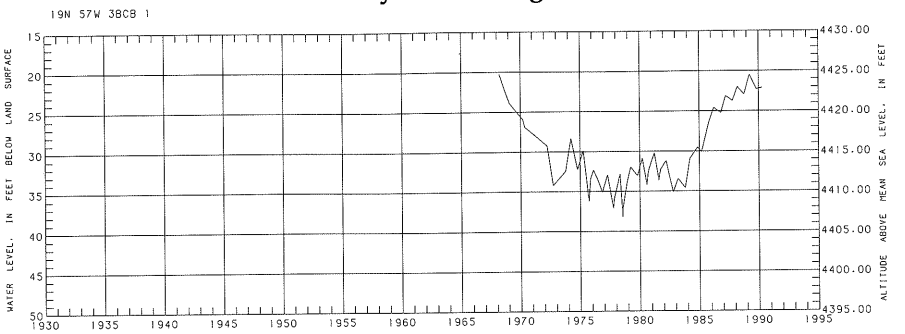
At the end of 1990, there were about 4,600 registered irrigation in the division. During 1990, 98 new wells were drilled and registered in the division. In addition to the districts already mentioned, the North Platte Natural Resources District also cooperated in the collection of the water-level data for this division.



Areas of significant water-level change in the Panhandle Division from 1946 to fall 1990

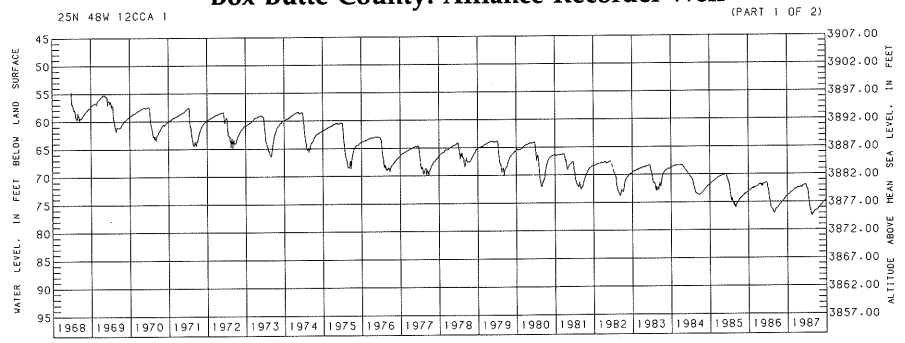
Banner County: Harrisburg West Well

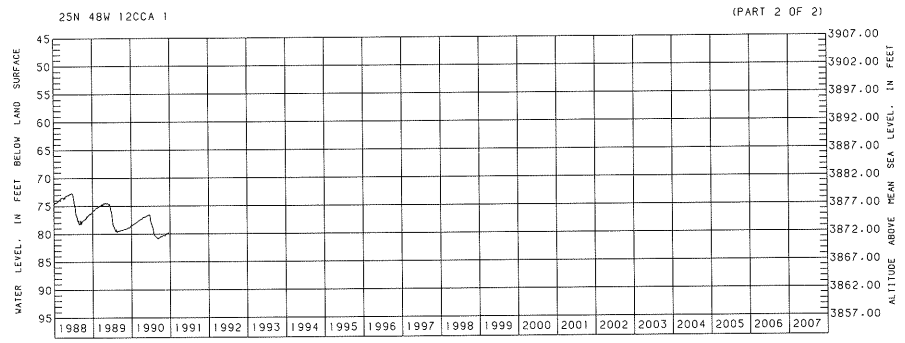
Estimated predevelopment water level: 19 feet
Well collapsed.



Box Butte County: Alliance Recorder Well

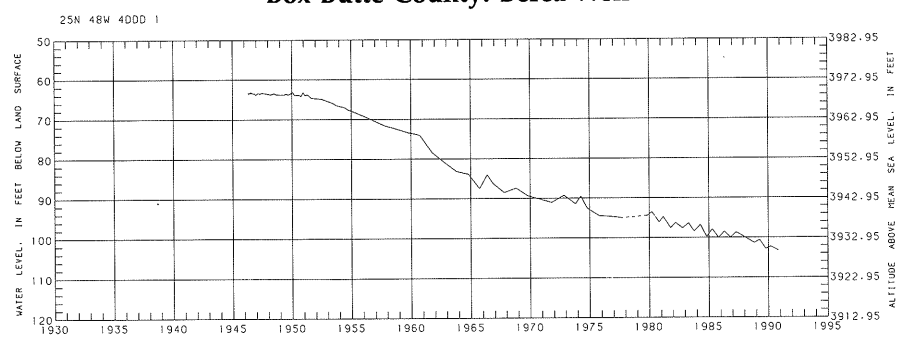
Estimated predevelopment water level: 17 feet
Net water-level change in 1990: -2.02 feet
Net water-level change since 1968: -23.16 feet





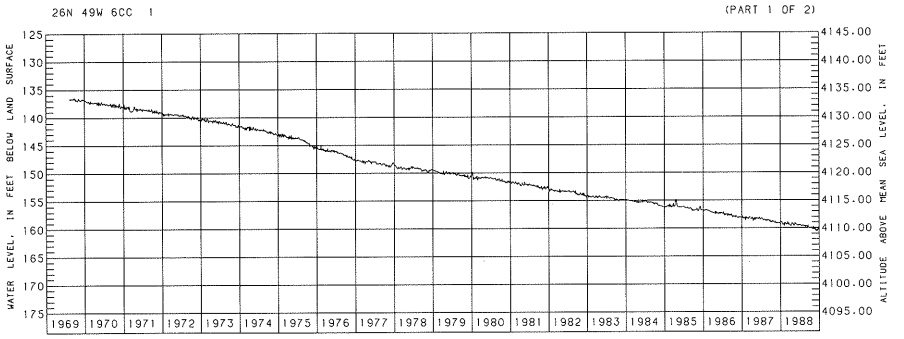
Box Butte County: Berea Well

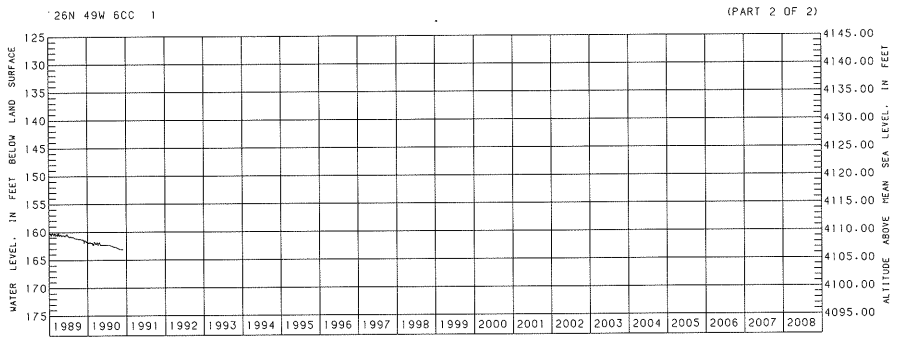
Measured semiannually
Estimated predevelopment water level: 63 feet
Net water-level change in 1990: -0.43 foot
Net water-level change since 1946: -39.76 feet



Box Butte County: Hemingford Recorder Well

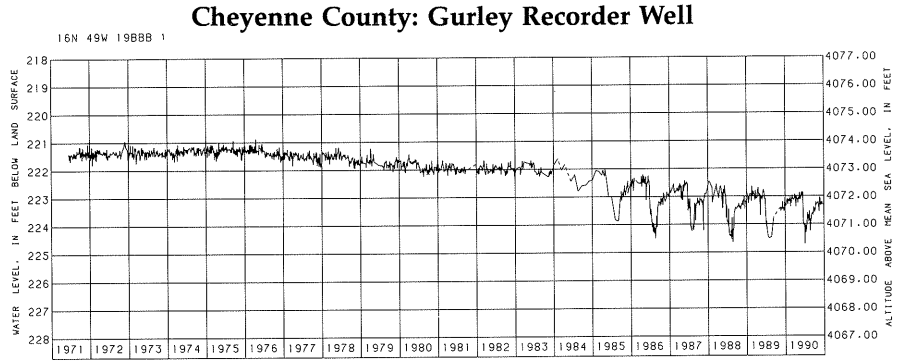
Estimated predevelopment water level: 134 feet
Net water-level change in 1990: -1.33 feet
Net water-level change since 1969: -26.24 feet





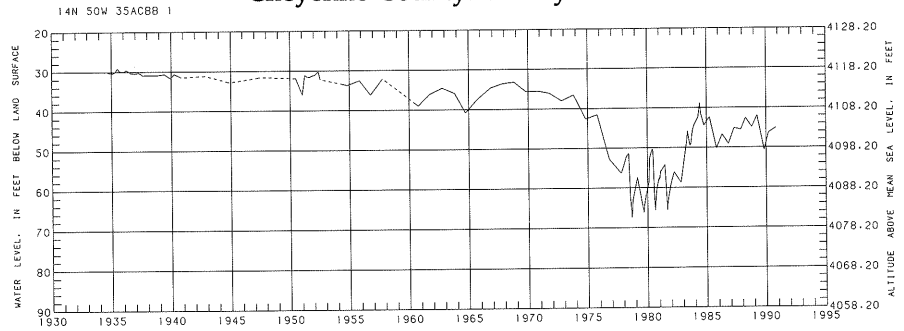
Cheyenne County: Gurley Recorder Well

Estimated predevelopment water level: 221 feet
Net water-level change in 1990: -0.05 foot
Net water-level change since 1971: -1.77 feet



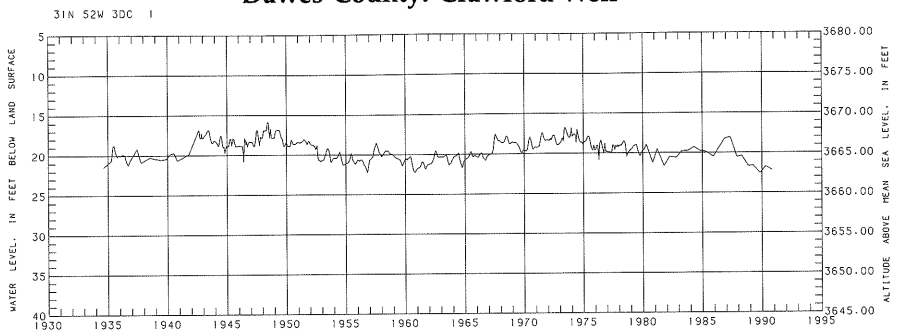
Cheyenne County: Sidney Well

Measured semiannually
Estimated predevelopment water level: 31 feet
Net water-level change, fall 1989 to fall 1990: +5.62 feet
Net water-level change since 1934: -14.73 feet



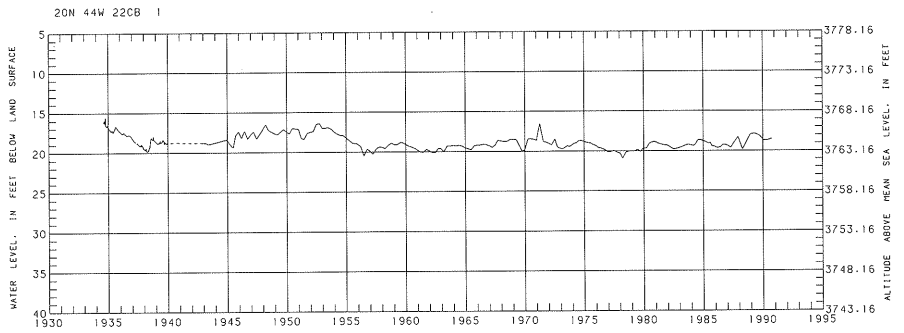
Dawes County: Crawford Well

Measured semiannually
Estimated predevelopment water level: 19.5 feet
Net water-level change, fall 1989 to fall 1990: +0.41 foot
Net water-level change since 1934: -0.99 foot



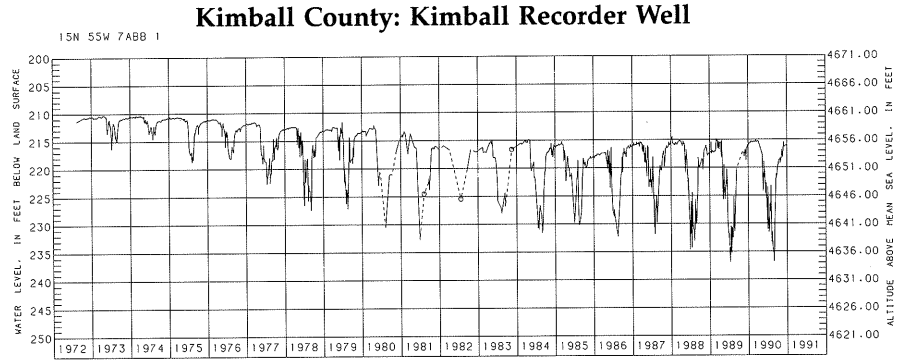
Garden County: Crescent Lake Well

Measured monthly
Estimated predevelopment water level: 17.5 feet
Net water-level change in 1990: -0.37 foot
Net water-level change since 1934: -1.66 feet



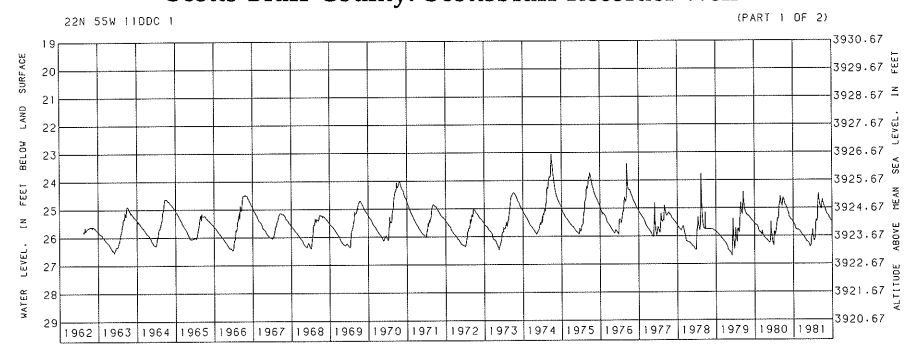
Kimball County: Kimball Recorder Well

Estimated predevelopment water level: 210 feet
Net water-level change in 1990: +0.08 foot
Net water-level change since 1972: -5.34 feet

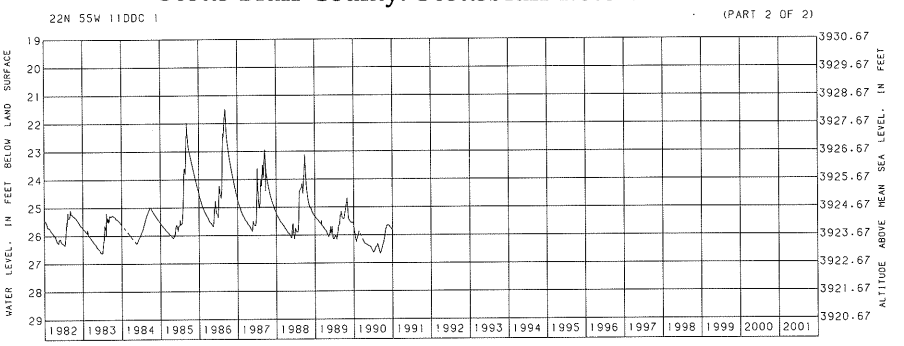


Scotts Bluff County: Scottsbluff Recorder Well

Estimated predevelopment water level: 26 feet
Net water-level change in 1990: -0.13 foot
Net water-level change since 1962: -0.01 foot

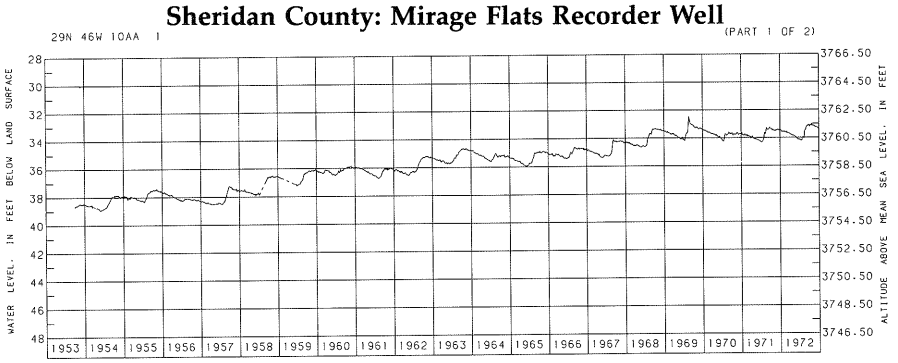


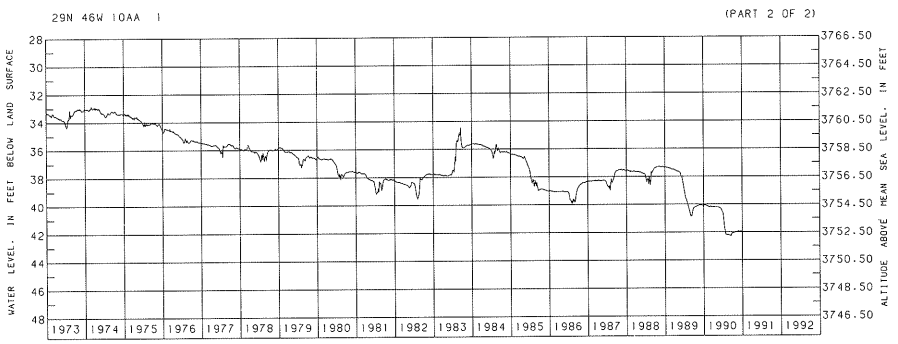
Scotts Bluff County: Scottsbluff Recorder Well



Sheridan County: Mirage Flats Recorder Well

Estimated predevelopment water level: 38.5 feet
Net water-level change in 1990: -1.86 feet
Net water-level change since 1953: -3.47 feet





Water-Level Measurement Program, 1990

Thirty-eight agencies collected water-level measurements that serve as basic data for this report.

Observation-well networks operated by 38 federal, state, and local agencies and municipalities provided the water-level data used in preparing this report. Water-level measurements are made for a variety of needs; therefore, the distribution of observation wells in the state is nonuniform. The number of observation wells per county ranges from none in Pawnee County, one or two in several other counties, to about 100 in others, with the greatest density in areas where significant changes in water levels have been recognized. Water-level changes in some areas, however, might not be detected or accurately delineated because of insufficient data.

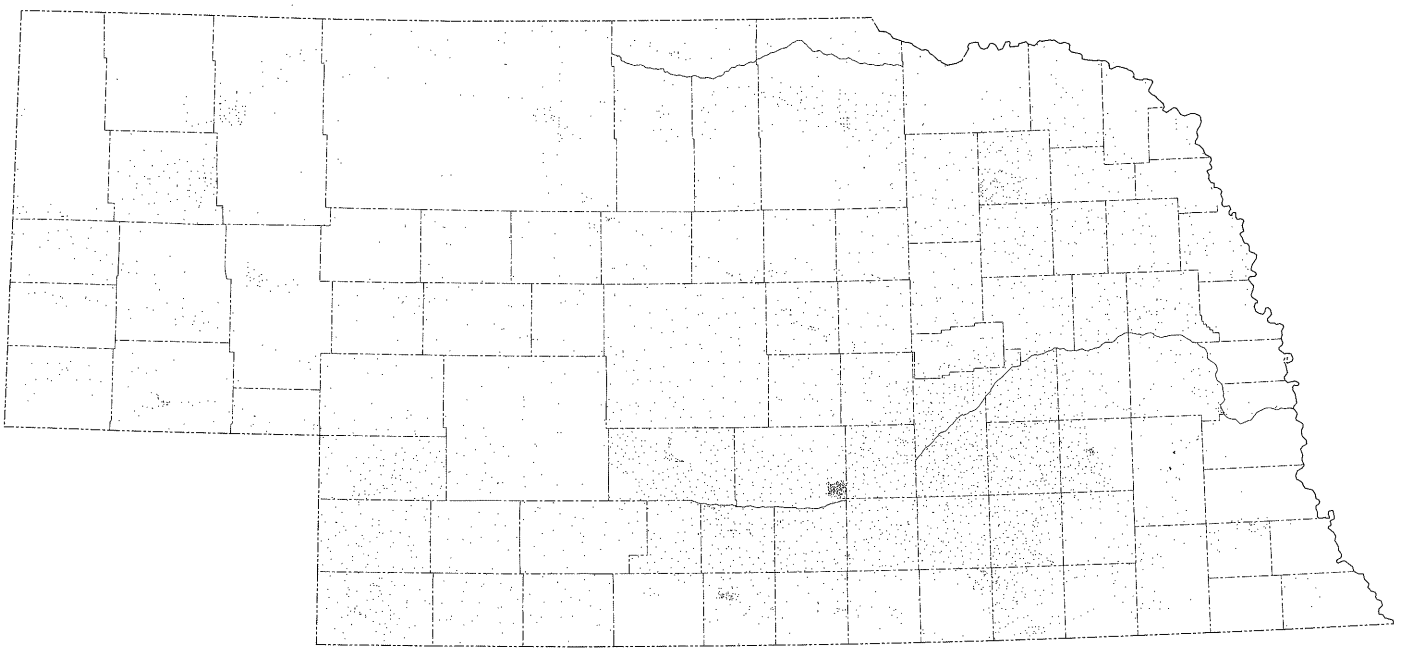
The location of all observation wells from which data were used in the preparation of this report are shown on the accompanying map. Measurements made in these wells are included in a computer file of historical water-level records maintained by the U.S. Geological Survey and the Conservation and Survey Division. As of December 31, 1990, this computer file contained records of approximately 494,000 water-level measurements made in about 17,300 wells. The number of water-level records available for each well is variable, depending on the number of years water levels have been measured in a well and the frequency of measurements. For some of these wells there are records of only one or two measurements made in a single year; whereas, for other wells there are several thousand records of measurements spanning 40 to 60 years. Records of water-level measurements included in the file can be obtained, on request, from the U.S. Geological Survey, Room 406, Federal Building, 100 Centennial Mall North, Lincoln, Nebraska 68508, or from the Conservation and Survey Division, University of Nebraska, 113 Nebraska Hall, Lincoln, Nebraska, 68588-0517.

As part of the cooperative groundwater program of the U.S. Geological Survey and the Conservation and Survey Division, the original observation-well network was designed to provide data only for a generalized appraisal of the state's groundwater resources. In time, a need to obtain detailed water-level data for specific areas led to the establishment of a number of local observation-well networks.

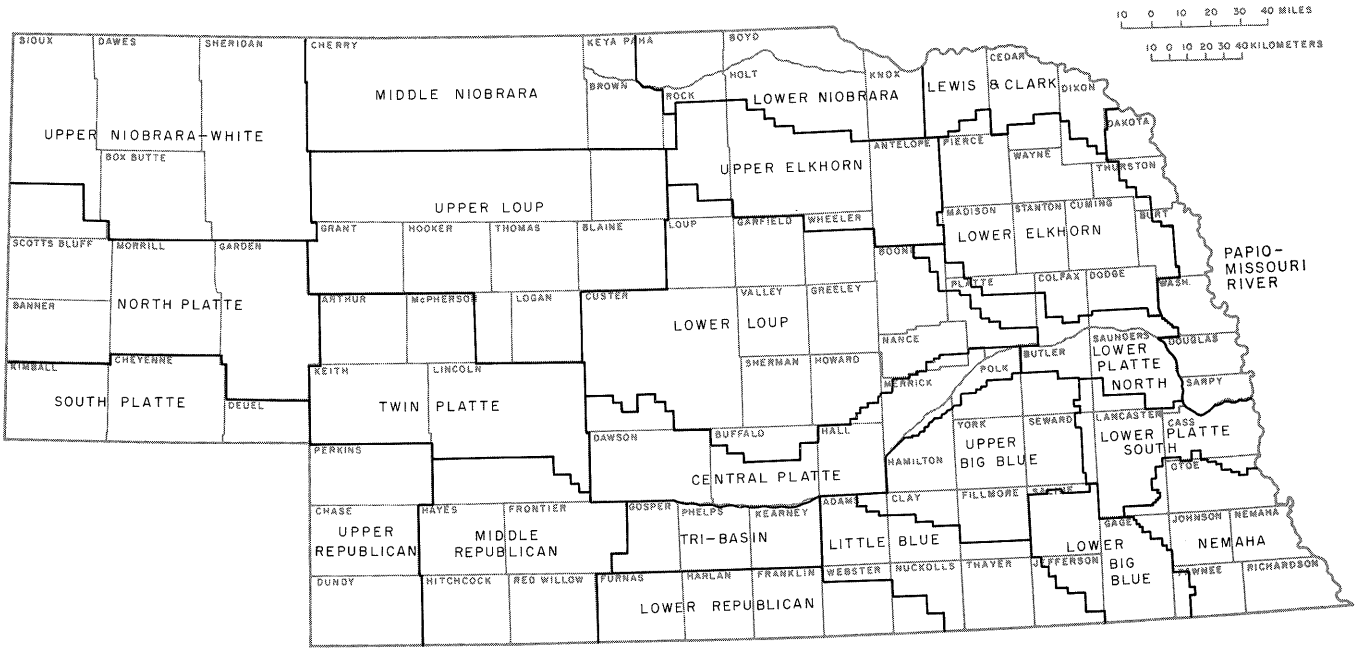
The need for water-level data to use in planning and evaluating the development of Nebraska's groundwater resources has changed the original cooperative water-level measurement program considerably. Currently, the program provides not only for the operation of a statewide observation-well network but also for assistance and advice to other agencies and associations in the establishment and operation of local observation-well networks, the operation and maintenance of a computer storage system for water-level data from all networks, and the evaluation and dissemination of water-level data.

About 16,000 water-level measurements were made in about 4,200 observation wells and were entered in the computer file of the cooperative water-level measurement program during 1990. Records from nearly all agencies in Nebraska making water-level measurements were compiled and entered into the file. The processing of these data and supporting information were major activities of the cooperative program.

The cooperation and assistance of the following agencies and associations in collecting and providing water-level data during 1990 are gratefully acknowledged: U.S. Bureau of Reclamation; U.S. Fish and Wildlife Service; Central Nebraska Public Power and Irrigation District; Harlan County extension agent; Nebraska Public Power District; groundwater conservation districts in Clay, Fillmore, Hamilton, Seward, and York counties; Omaha Metropolitan Utilities District; Lincoln Water System; and the following natural resources districts: Lower Republican, Middle Republican, Upper Republican, Upper Big Blue, Little Blue, Lower Big Blue, Lower Platte South, Lower Platte North, Central Platte, Twin Platte, North Platte, South Platte, Lower Niobrara, Middle Niobrara, Upper Niobrara-White, Lower Loup, Upper Loup, Lower Elkhorn, Upper Elkhorn, Papio-Missouri River, Lewis and Clark, Nemaha, and Tri-Basin.



Location of water-level observation wells in Nebraska



Location of Nebraska natural resources districts

During the 1990 growing season, half of Nebraska's eight climatic divisions received near normal precipitation and the remaining divisions received slightly less-than-normal precipitation.

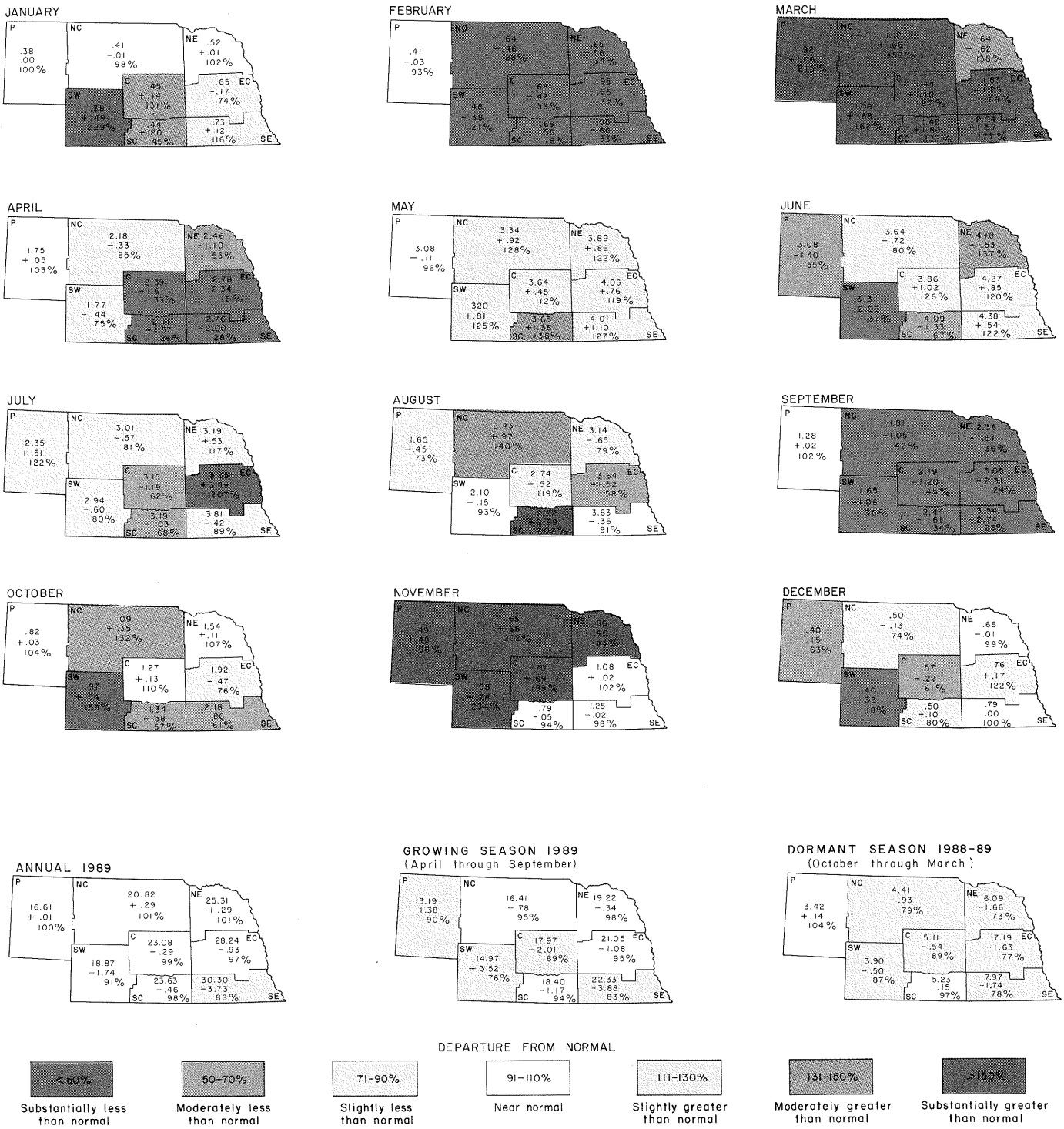
Effect of Precipitation on Groundwater Levels During 1990

During 1990, seven of Nebraska's eight climate divisions received near the 30-year average for precipitation (normal). (The boundaries of the climate divisions established by the National Oceanic and Atmospheric Administration generally do not coincide with the divisions used in this report to describe water-level changes.) The Southeast Division received slightly less than normal (88 percent). The number of divisions that received normal precipitation during 1990 was a significant change from 1989, when all divisions received less-than-normal precipitation. Although the 1990 annual precipitation was near normal for seven climate divisions, only four received normal precipitation during the growing season, when the need for groundwater to supply domestic, municipal, and agricultural uses is greatest. The other four climate divisions received slightly less-than-normal precipitation during the growing season. May was the only month during the 1990 growing season in which all eight divisions received at least normal precipitation. April and September were the only months during the growing season in which the Panhandle Division received normal precipitation, while the other divisions received slightly less to substantially less than normal. For the entire 1990 growing season, precipitation ranged from near normal in the North-Central, North-East, East-Central and South-Central divisions to slightly less than normal in the other four divisions.

During the 1989-90 dormant season, precipitation generally ranged from normal in the Panhandle and South-Central divisions to slightly below normal for the other six divisions. During October and November 1989, all eight divisions had less-than-normal precipitation and in February 1990, all except the Panhandle Division had substantially less-than-normal precipitation.

March 1990 was the only month during the 1989-90 dormant season in which all of the climate divisions had above-normal precipitation. As a result, many irrigators did not start applying water prior to planting, as they did in 1989; therefore, water levels did not start declining as soon as they did in 1989. Abundant precipitation in March 1990 also helped lessen the overall affect of the less-than-normal dormant season precipitation; however, available water-level data indicate that most spring 1990 water levels were still 1 to 2 feet lower than 1989 levels.

Almost all recharge to aquifers in Nebraska comes from precipitation that infiltrates into the ground near where it falls. In some localities, however, seepage from streams, lakes, irrigation canals, and applied irrigation water can be a more important source of recharge than precipitation. No precise quantitative relationship has been determined between precipitation amounts and the resultant groundwater-level changes, but a general correlation between precipitation and water-level fluctuations can be noted from most of the records. Precipitation also can affect water levels indirectly, because the quantities of water pumped for irrigation and municipal use generally are less during wet periods and greater during dry periods.



Summary of monthly, seasonal, and total precipitation in 1990 for eight National Weather Service divisions of Nebraska showing average precipitation in inches, positive or negative departure from normal precipitation in inches, and the percentage of normal precipitation

Groundwater Use and Development

Distribution of Irrigation Wells

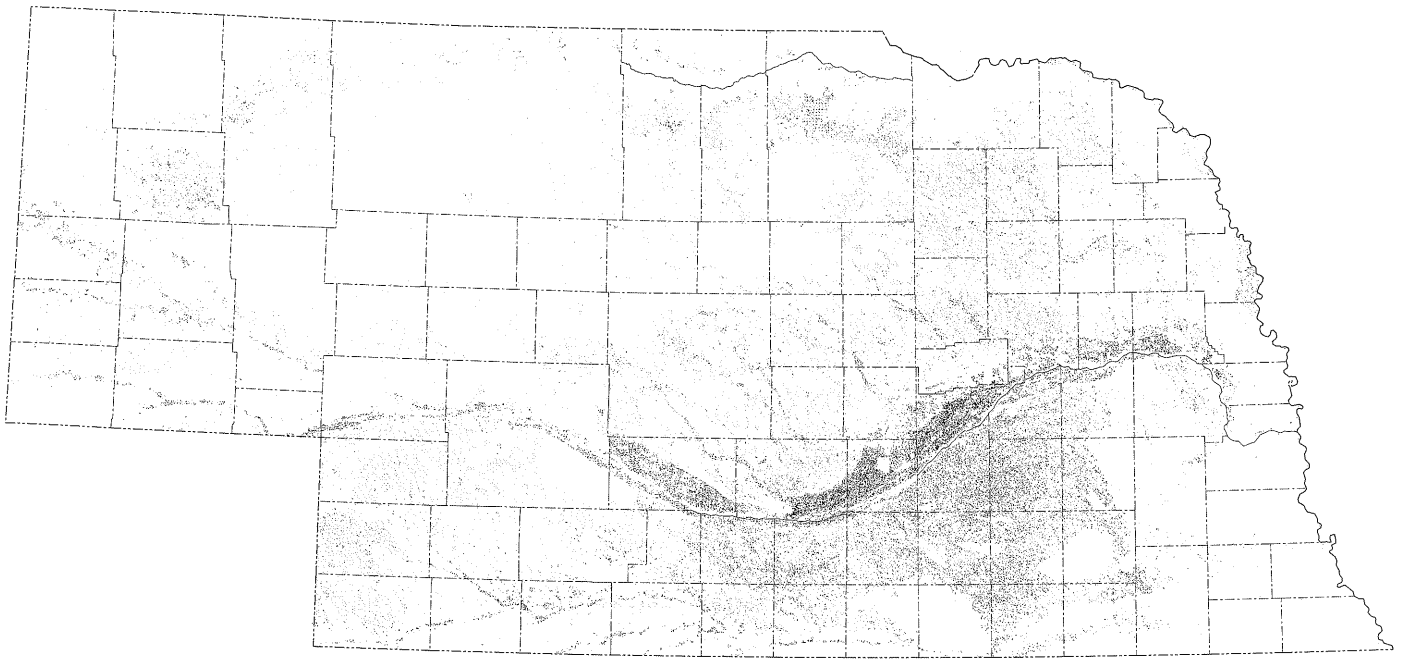
The approximately 5 million acre-feet of groundwater used for irrigation in 1990 is about 16 times the amount of groundwater used for all other uses in Nebraska.

At the end of 1990, a total of 74,048 irrigation wells had been registered in Nebraska. These wells are the source of water for irrigating approximately 86 percent of the estimated 6.9 million acres of irrigated land in the state. The volume of groundwater pumped for irrigation in 1990 was estimated to be about 5 million acre-feet (Z.D. Hill, oral communication, 1991). This amount was about 16 times more than the total volume of groundwater pumped for domestic, livestock, municipal, industrial, and other uses.

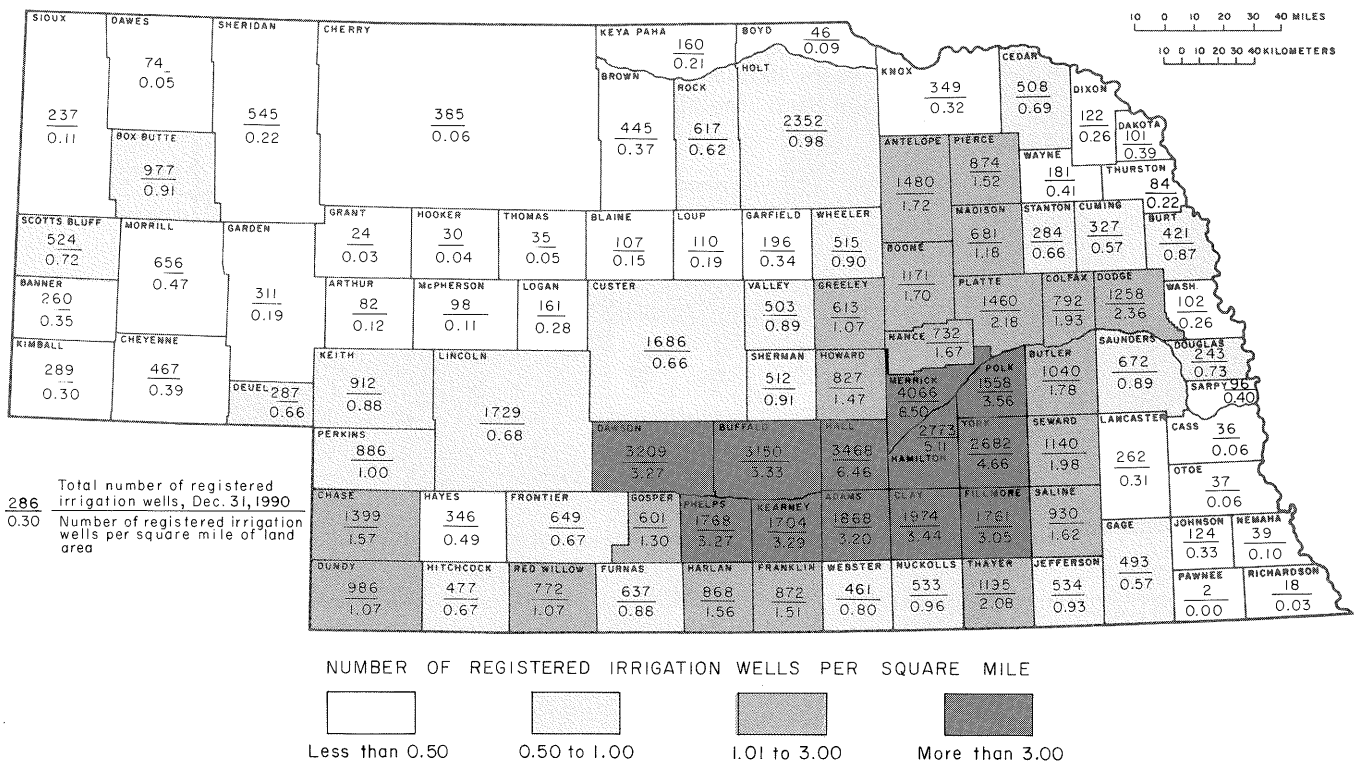
Although irrigation wells have been drilled in each of Nebraska's 93 counties, their number and density differ greatly from one county to another because of variations in land use, distribution of irrigable land, and availability of groundwater. Approximately 47 percent of the registered irrigation wells are concentrated in a 16-county area comprising the upper part of the Big Blue River and Little Blue River basins, and the central part of the Platte River valley. Buffalo, Dawson, Hall, Hamilton, Merrick, and York counties have more than 2,600 irrigation wells each; the nearby counties of Adams, Butler, Clay, Fillmore, Kearney, Phelps, Platte, Polk, Seward, and Thayer have more than 1,000 irrigation wells each. Antelope, Boone, Chase, Custer, Dodge, Holt, and Lincoln counties are the only other counties in the state that have more than 1,000 irrigation wells each.

Although the total number of irrigation wells in a county provides some indication of the degree of groundwater development that has taken place, the number of irrigation wells per square mile of land area in a county is a better index of the degree of development. A high density of irrigation wells in a county generally indicates both a large percentage of irrigable land and a large volume of available groundwater. Very low densities generally characterize counties where development is limited either by little irrigable land or by aquifers that yield only a small volume of water to wells, or both. Merrick County, with an average of 8.5 irrigation wells per square mile of land area, has the highest well density of any county in the state. Pawnee County, with an average of about one irrigation well per 216.5 square miles, has the lowest well density in the state.

By far the largest use of groundwater in Nebraska is for irrigation, and most of the concern about changes in water levels and availability of groundwater is related to irrigation development. Use of groundwater for rural domestic, livestock, industrial, and municipal supplies, however, also is important. Groundwater is used for almost all rural domestic and livestock supplies; for almost all industrial supplies; and for all municipal supplies except for Crawford, Beaver Lake, Blair, and part of Omaha's, Crofton's, and Chadron's supplies.



Location of registered irrigation wells in Nebraska as of December 31, 1990



Total number and density of registered irrigation wells in Nebraska, by county, as of December 31, 1990

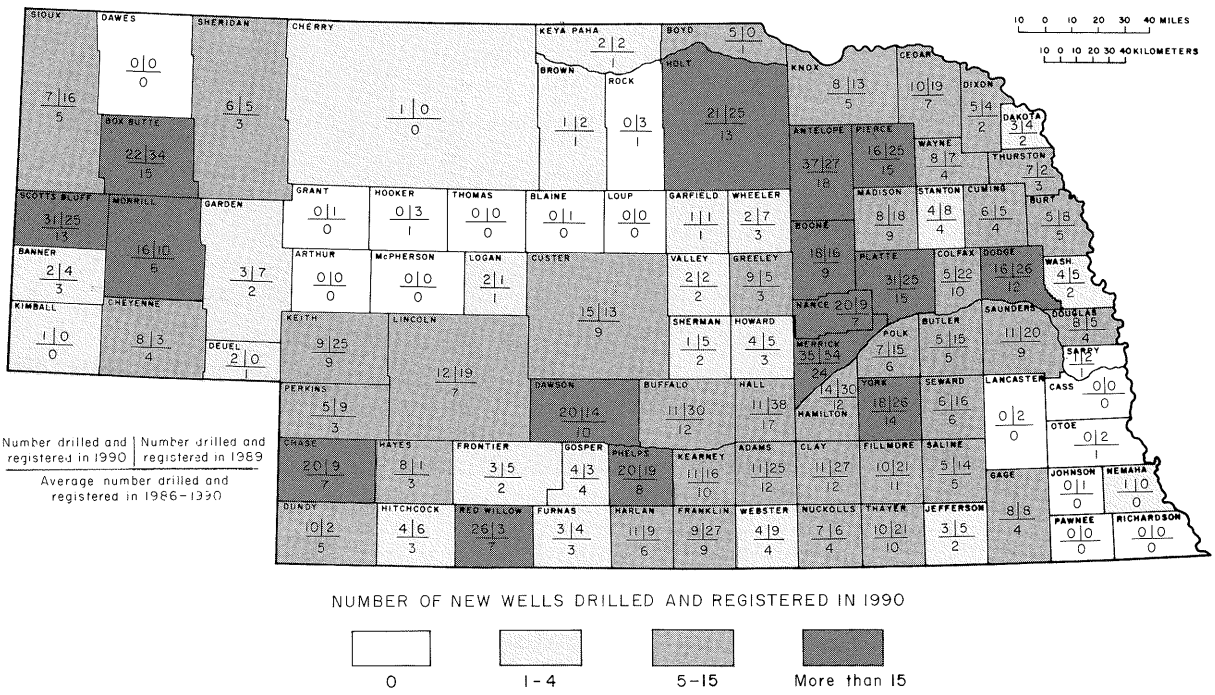
The 747 new irrigation wells drilled and registered during 1990 was a 24 percent decrease from the new wells drilled and registered in 1989.

Trends in Groundwater Development

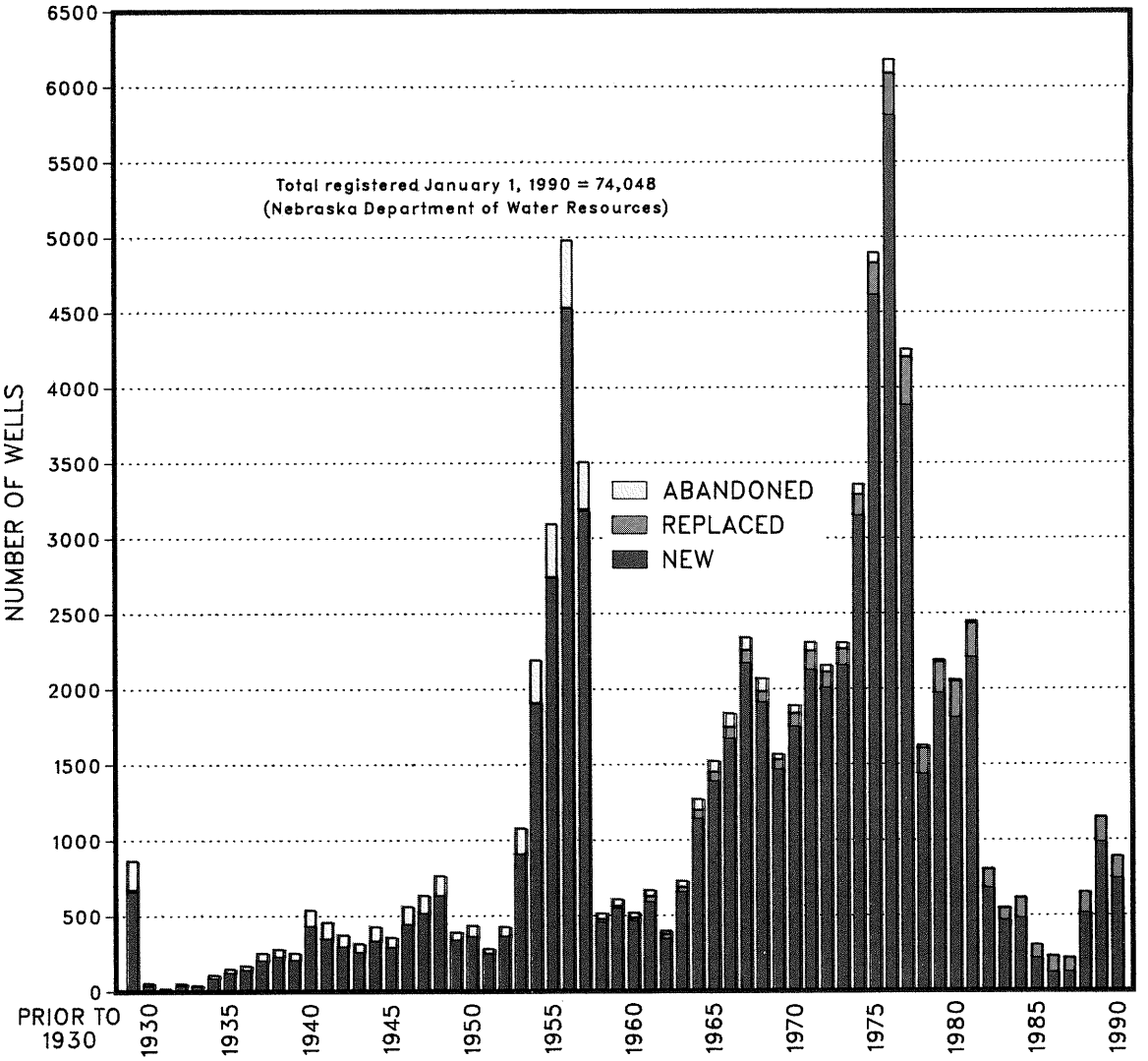
Irrigation has been one of the most important factors in making Nebraska a leading state in agricultural productivity. During the past three decades, groundwater use to meet agricultural demands has more than tripled, so that now about 70 percent of the water used for irrigation is pumped from wells. During 1990, 747 new irrigation wells were drilled and registered in Nebraska. This is 24 percent lower than the amount of wells drilled and registered in Nebraska during 1989. These new irrigation wells were drilled in 79 of the state's 93 counties. Thirty-seven of the new irrigation wells were drilled in Antelope County, 35 were drilled in Merrick, 31 each in Platte and Scotts Bluff counties, and more than 20 were drilled in Box Butte, Chase, Dawson, Holt, Nance, Phelps, and Red Willow counties.

A combination of economic, climatic, and technological factors account for annual variations in the number of irrigation wells drilled. During periods of less-than-normal precipitation, such as the growing seasons in the years 1953-56, the number of irrigation-well installations increased markedly. Increased drilling commonly continues for a year or more after a drought. Starting in the mid-1960s, increased development was affected by short droughts, the availability of center-pivot irrigation systems, and favorable economic conditions, especially during 1973-75.

The large number of irrigation wells installed during 1990 probably can be explained by the continuation of well installations following the drought of 1988-89 and the awareness that drought conditions and less-than-normal precipitation during the growing season can continue.



Number of registered irrigation wells drilled in Nebraska in 1990, 1989, and 1986-90, by county



Annual installation of irrigation wells in Nebraska through 1990 (estimated from historical surveys and irrigation-well registrations)

A water-level hydrograph provides a graphic representation of water-level fluctuations.

Explanation of Water-Level Hydrographs

Hydrographs are used to illustrate seasonal and long-term water-level fluctuations in observation wells measured to indicate hydrologic conditions at various locations in each division. The observation wells selected include those with continuous recorders and others that are measured periodically. In recorder wells, a float system or an electronic sensor is used to detect depths to water, which are recorded graphically on a chart or digitally on punched tape or in an electronic data logger. Only limited data from continuous recorders can be stored, so only the lowest daily value for every fifth day and the end of the month is stored in computer files. Water levels in wells measured periodically are recorded annually (in the fall), semiannually (in the spring and fall), or monthly. Hydrographs for recorder wells provide a detailed record of water-level changes. Hydrographs of wells measured periodically might not show extremes in water-level fluctuations as well as those with continuous recorders, but they provide important information on long-term water-level trends.

In addition, the bottom of a hydrograph does not represent the bottom of the aquifer. The full range of water-level fluctuations, in most wells, usually is only a fraction of the thickness of the aquifer.

An annotated hydrograph of a 20-year segment (1948-67) of the record for the Alda (old) recorder well is used to show some of the interpretations possible with hydrographs. This well is located in Hall County about 2 miles west-northwest of Alda. Water-level rises in this well were due principally to recharge from precipitation. Except for small volumes of water withdrawn occasionally to ensure that the well screen was clear, water was not pumped from this well, so declines were due to pumping from nearby wells and natural discharge. In this well, as in many wells in Nebraska, water levels generally were highest in late spring, declined during the growing season, and began to rise again in October or November. More pronounced growing-season declines and fall recoveries are indicative of large volumes of water being pumped from nearby wells. When the water level is higher at the end of the year than at the beginning, the difference indicates a net gain in groundwater storage. Conversely, when the water level is lower, the difference indicates a net loss. Changes in water levels are not equal to changes in the volume of groundwater stored. Because groundwater occurs only in the pore spaces between the rock grains of the aquifer (for example, about 30 to 35 percent by volume for sand and gravel), a 3-foot change in water levels might be equal to about a 1-foot change in the volume of water stored.

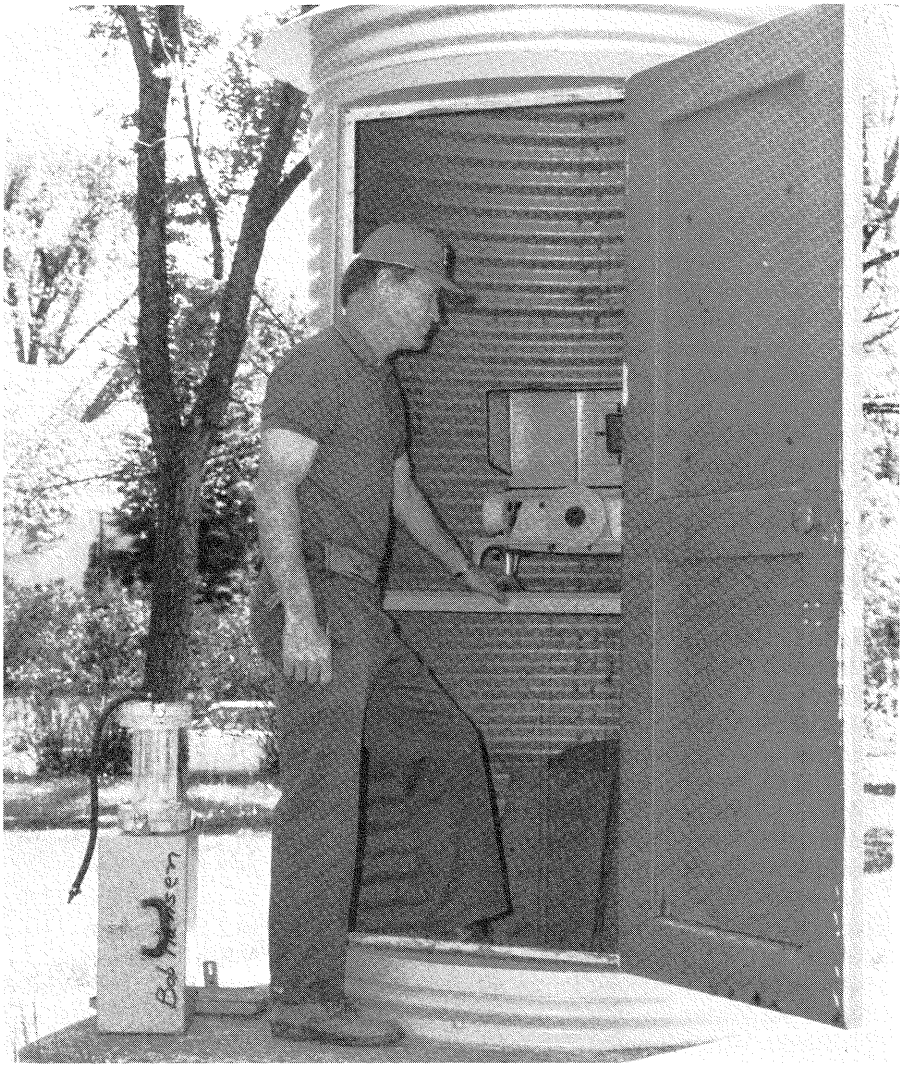
At the beginning of the annotated hydrograph shown for the Alda (old) recorder well, the depth to water was a little greater than 16 feet (A), or a little more than 1 foot lower than the estimated predevelopment water level (bold dashed line). Abrupt water-level rises occurred near the middle of many years, such as in 1949 (B) and 1967 (E), because of major precipitation. On June 15, 1967, 7-10 inches of rain fell and caused the 1967 rise; it also caused flooding in the area.

During the first 5 years of water-level records, depths to water at the end of each year were nearly the same as at the beginning. This indicates that discharge from the aquifer by natural processes and by pumping from wells was about equal to recharge from infiltrating precipitation. From 1953 through 1956, water-level declines due to natural discharge and to pumping for irrigation exceeded recharge from precipitation. As a result, year-end depths to water were lower than at the start of each year; during this period, the net water-level decline was 7.5 feet. Both 1955 and 1956 were very dry, and fall water-level recoveries were small following large water-level declines caused by irrigation pumping (C and D).

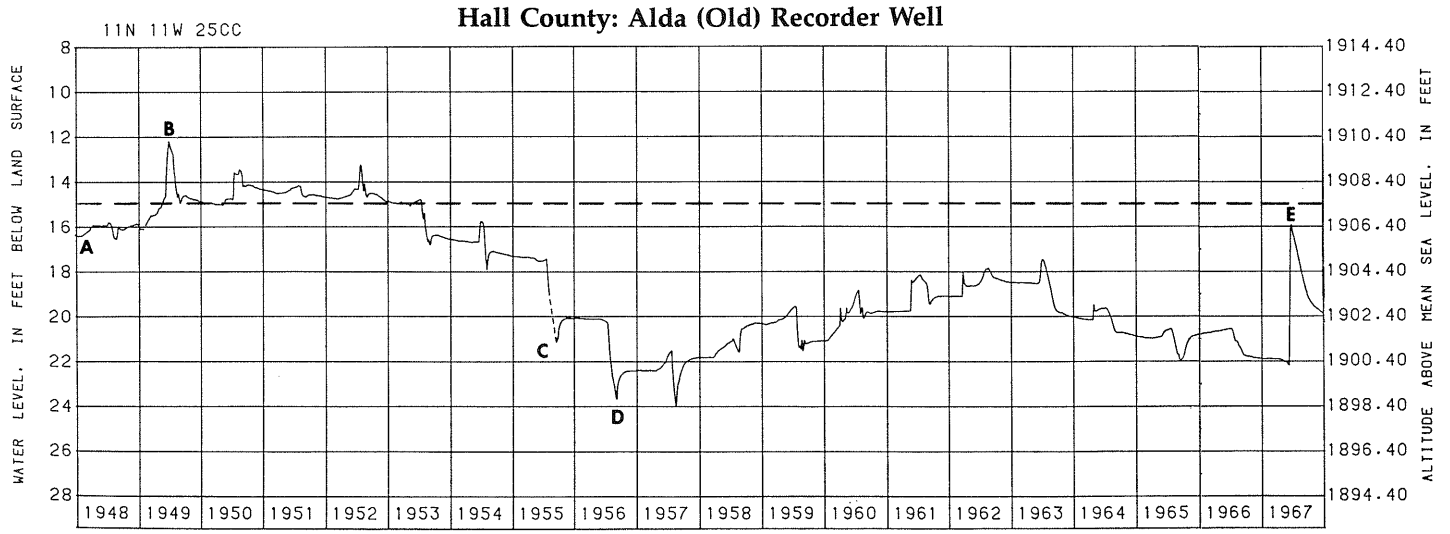
During the following 6 years (1957-1962), recharge from ample precipitation and less irrigation pumping combined to result in a net water-level rise of about 4 feet. During 1963-1966, year-end depths to water again were progressively lower; but in 1967 the year-end water level was 2 feet higher than at the beginning of the year. Although water levels in the Alda (new) recorder well were as low as 26 feet in 1981, by the end of 1986 they were almost the same as the 1948 levels in the Alda (old) recorder well. Readers interested in examples of hydrographs that show confined, unconfined and perched aquifers should see the section, "Examples of Water-Level Hydrographs," in the 1987 report, "Groundwater Levels in Nebraska, 1986."

References

National Oceanic and Atmospheric Administration, 1990, Climatological Data for Nebraska, annual and monthly summaries: Asheville, NC, National Climatic Data Center.



Bob Hansen, basic-data supervisor with the Conservation and Survey Division, gets ready to check a water-level measurement.



Annotated example of a water-level hydrograph

Reports Containing Water-Level Information

Year of observation	Publication and number	Author(s) and year published
pre-1954	U.S. Geol. Survey Open-File Rpt. 54-138	Keech, C.F.; Case, R.L., 1954
1954	U.S. Geol. Survey Open-File Rpt. 55-80	Keech, C.F.; Case, R.L., 1955
1955	U.S. Geol. Survey Open-File Rpt. 56-70	Keech, C.F.; 1956
1956	U.S. Geol. Survey Open-File Rpt. 57-61	Keech, C.F., 1957
1957	Nebraska Water Survey Paper 4*	Keech, C.F., 1958
1958	Nebraska Water Survey Paper 5*	Keech, C.F., 1959
1959	Nebraska Water Survey Paper 6	Keech, C.F., 1960
1960	Nebraska Water Survey Paper 9	Keech, C.F., 1961
1961	Nebraska Water Survey Paper 12	Keech, C.F.; Hyland, J.B., 1962
1962	Nebraska Water Survey Paper 13	Emery, P.A.; Malhoit, M.M., 1963
1963	Nebraska Water Survey Paper 14	Emery, P.A.; Malhoit, M.M., 1964
1964	Nebraska Water Survey Paper 17	Emery, P.A.; Malhoit, M.M., 1965
1965	Nebraska Water Survey Paper 18	Emery, P.A.; Malhoit, M.M., 1966
1966	Nebraska Water Survey Paper 20	Keech, C.F., 1967
1967	Nebraska Water Survey Paper 23	Keech, C.F., 1968
1968	Nebraska Water Survey Paper 24	Keech, C.F.; Svoboda, G.R., 1969
1969	Nebraska Water Survey Paper 26*	Keech, C.F., 1970
1970	Nebraska Water Survey Paper 28*	Keech, C.F., 1971
1971	Nebraska Water Survey Paper 33	Keech, C.F., 1972
1972	Nebraska Water Survey Paper 34	Ellis, M.J.; Pederson, D.T., 1976
1973	Nebraska Water Survey Paper 36	Ellis, M.J., 1974
1974	Nebraska Water Survey Paper 40*	Ellis, M.J., 1975
1975	Nebraska Water Survey Paper 43	Ellis, M.J.; Pederson, D.T.,
1976	Nebraska Water Survey Paper 44	Ellis, M.J.; Pederson, D.T., 1977
1977	Nebraska Water Survey Paper 45	Ellis, M.J.; Pederson, D.T., 1978
1978	Nebraska Water Survey Paper 49	Pederson, D.T.; Johnson, M.S., 1979
1979	Nebraska Water Survey Paper 50	Johnson, M.S.; Pederson, D.T., 1980
1980	Nebraska Water Survey Paper 51	Johnson, M.S.; Pederson, D.T., 1981
1981	Nebraska Water Survey Paper 52	Johnson, M.S.; Pederson, D.T., 1982
1982	Nebraska Water Survey Paper 56	Johnson, M.S.; Pederson, D.T., 1983
1983	Nebraska Water Survey Paper 57	Johnson, M.S.; Pederson, D.T., 1984
1984	Nebraska Water Survey Paper 59	Ellis, M.J.; Pederson, D.T., 1985
1985	Nebraska Water Survey Paper 61	Ellis, M.J.; Pederson, D.T., 1986
1986	Nebraska Water Survey Paper 62	Ellis, M.J.; Dreeszen, V.H., 1987
1987	Nebraska Water Survey Paper 65	Ellis, M.J.; Wigley, P.B., 1988
1988	Nebraska Water Survey Paper 66	Ellis, M.J.; Steele, G.V.; and Wigley, P.B., 1989
1989	Nebraska Water Survey Paper 67	Ellis, M.J.; Steele, G.V. and Wigley, P.B., 1990

* Out of print; but available for study at USGS or division offices

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